

HURRICANE SURVEY



INTERIM REPORT

NEW LONDON

CONNECTICUT

APPENDICES



**U.S. Army Engineer Division, New England
Corps of Engineers
Waltham, Mass.**

26 April 1961

31

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 Trapelo Road
Waltham 54, Mass.

Refer to File No.
NEDGW

14 July 1961

NOTICE OF REPORT ON HURRICANE TIDAL-FLOOD PROTECTION,
NEW LONDON, CONNECTICUT

Notice is hereby given that the report on the advisability of providing protection against hurricane tidal-flooding at New London, Connecticut, authorized by Public Law 71, 84th Congress, approved 15 June 1955, and concerning which a public hearing was held on 27 June 1960 at New London, Connecticut, has been made by the Division Engineer and the report is favorable to the improvement.

The Division Engineer finds that the New London area has sustained heavy damages from tidal-flooding in three great hurricanes of the past 20 years and is faced with the threat of severe tidal-flood damages in future hurricanes. He recommends for New London, Connecticut, the construction of an earth-fill, rock faced barrier with a gated small boat opening in the vicinity of Powder Island; an earth-fill, rock faced barrier with a gated navigation opening in the vicinity of Shaw Cove, and appurtenant structures.

The estimated first cost to the United States is \$2,401,000 and to local interests \$1,029,000, a total first cost of \$3,430,000. The construction is recommended subject to the condition that local interests participate as follows:

(1) Provide without cost to the United States all necessary lands, easements, and rights-of-way, including borrow areas and spoil disposal areas necessary for construction of the project.

(2) Hold and save the United States free from damages due to the construction works.

(3) Maintain and operate all features of the project, with the exception of aids to navigation, after its completion, in accordance with regulations prescribed by the Secretary of the Army. The annual cost of operation and maintenance by local interests, including major replacements, is estimated at \$26,000.

(4) Accomplish without cost to the United States all modifications or relocations of existing sewerage and drainage facilities, buildings, utilities and highways made necessary by the construction of the project.

(5) Bear 30 percent of the total first cost, a sum presently estimated at \$1,029,000, consisting of the items listed in (1) and (4) above, and a cash contribution now estimated at \$819,000, the cash to be paid prior to commencement of construction, and the final allocation of cost to be made after actual costs and values have been determined.

In accordance with law, the report is being referred for review to the Board of Engineers for Rivers and Harbors in Washington, D. C. Interested parties may present written views on the report to the Board. Statements submitted should not repeat material previously presented at public hearing held by the Division Engineer, or contained in the report, as this information is already available to the Board. Information submitted should be new, specific in nature, and bear directly on the findings in the report.

Hearings will be held only on written request explaining the need to present material not included in the report.

Written communications are to be mailed to the Board of Engineers for Rivers and Harbors, Washington 25, D. C., in time to reach the Board by 14 August 1961. If extension of this date is considered necessary, requests giving reasons and additional time desired should be submitted as soon as possible.

The Board considers communications and the report at a date subsequent to expiration of notice. Information furnished by mail receives the same attention as that received at a public hearing. Should the Board not be convinced of the soundness of the recommendations in the report, notice to that effect will be mailed to all known interested parties prior to final action.

Further information may be obtained from this office, 424 Trapelo Road, Waltham 54, Massachusetts. Interested parties, including the press, may make such notes of the contents of the report as they desire. However, copies of the report will not be loaned for use outside of the office, but interested parties may purchase copies of the report, or parts thereof, including illustrations, at the cost of reproduction. Copies may be purchased from the Division Engineer, U. S. Army Engineer Division, New England, Corps of Engineers, 424 Trapelo Road, Waltham 54, Massachusetts, at a cost of \$2.00 for the Main Report and \$2.00 for the second volume containing the Appendices. Checks or money orders should be made payable to "Treasurer of the United States."

You are requested to give the foregoing information to any persons known by you to be interested in the report, and who, not being known by the Division Engineer, do not receive a copy of this public notice.

SEYMOUR A. POTTER, JR.
Brigadier General, USA
Division Engineer

APPENDICES

GLOSSARY

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- APPENDIX B - HYDROLOGY AND HYDRAULICS
- APPENDIX C - FLOOD LOSSES AND BENEFITS
- APPENDIX D - DESIGN STUDIES AND COST ESTIMATES
- APPENDIX E - LETTERS OF COMMENT AND CONCURRENCE

GLOSSARY

- HURRICANE SURGE:** the mass of water causing an increase in the elevation of the water surface above predicted astronomical tide at the time of a hurricane; it includes wind setup; sometimes the maximum increase in elevation is referred to as the surge.
- HURRICANE TIDE:** the rise and fall of the water surface during a hurricane exclusive of wave action.
- KNOT:** a velocity equal to one nautical mile (6080.2 feet) per hour (about 1.15 statute miles per hour).
- OVERTOPPING:** that portion of the wave runup which goes over the top of a protective structure.
- PONDING:** the storage of water behind a dike or wall from local runoff and/or overtopping by waves.
- POOL BUILDUP:** the increase in elevation of water surface behind a structure due to runoff and/or overtopping by waves.
- RUNUP:** the rush of water up the face of a structure on the breaking of a wave. The height of runup is measured from the still water level.
- SIGNIFICANT WAVE:** a statistical term denoting waves with the average height and period of the one-third highest waves of a given wave train.
- SPRING TIDE:** a tide that occurs at or near the time of new and full moon and which rises highest and falls lowest from the mean level.
- STANDARD PROJECT HURRICANE:** a storm that may be expected from the most severe combination of meteorologic conditions that are considered reasonably characteristic of the region involved, excluding rare combinations.
- STILL WATER LEVEL:** the elevation of the water surface if all wave action were to cease.
- STORM SURGE:** same as "hurricane surge".
- WAVE HEIGHT:** the vertical distance between the crest and the preceding trough.

GLOSSARY (Cont'd.)

WAVE TRAIN: a series of waves from the same direction.

WIND SETUP: the vertical rise in the still water level on the leeward side of a body of water caused by wind stresses on the surface of the water.

APPENDIX A

HISTORY OF HURRICANES AND OTHER STORM OCCURRENCES

APPENDIX A

APPENDIX A

HISTORY OF HURRICANE AND OTHER STORM OCCURRENCES

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APPENDIX A

HISTORY OF HURRICANE AND OTHER STORM OCCURRENCES

A-1. GENERAL

In order to determine the possibility of future hurricane occurrences, a review has been made of historical data on hurricanes that have struck or threatened the coasts of western Rhode Island and eastern Connecticut. A review of historical records and newspaper files indicates that a number of hurricanes and cyclonic storms have reached the coast of southern New England with devastating force, while numerous other storms have passed so close that a slight change in meteorologic conditions could have resulted in severe damage. Since the eastern entrance of Long Island Sound lies in the path of hurricanes moving into New England from the south, the Connecticut shore line, on the north of the Sound, has frequently been subject to tidal flooding from hurricane surges moving west up the Sound. The records indicate that from 1635 to present the eastern Connecticut coast has experienced or has been threatened by hurricane tidal flooding upon 69 occasions. Of these hurricanes 32 either weakened by the time they neared New London or passed far enough away so that they did not cause tidal flooding. They did, however, present a potential threat of such flooding. Apparently 37 hurricanes caused tidal flooding. Records, exclusive of historical accounts prior to 1800, indicate that the five hurricanes which have created the most severe tidal flooding along the Connecticut coast are as follows, chronologically:

23 September 1815
24 August 1893
21 September 1938
14 September 1944
31 August 1954

The earliest hurricanes recorded in New England are known to have affected the coastal areas of Massachusetts and Rhode Island. Since there was very little development along the Connecticut shore until after 1638, there are no available records to indicate that these early storms affected Long Island Sound. It is reasonable to assume that they did cause inundation of the coastal lowlands of eastern Connecticut, as the hurricanes of recent years that have caused tidal flooding along the coasts of southern Massachusetts and Rhode Island also caused flooding along the Connecticut coast. The two earliest hurricanes of record in New England, namely those of 15 August 1635 and 3 August 1638, created flood levels apparently higher than the recent floods of 1938 and 1954, and probably the greatest experienced in New England during the past 326 years.

The early hurricanes were not accompanied by so great a loss of life and property due to the lesser degree of development along the Connecticut coast. However, the recurrence of the two earliest hurricanes under present conditions would cause extensive damages, possibly in excess of the damages sustained in September 1938.

In addition to the above hurricanes, there have been other severe storms, not necessarily of tropical origin, that caused considerable damage along the Connecticut coast (see Table A-2). An examination of the U. S. Coast and Geodetic Survey tide-gage records at New London Harbor, Connecticut, indicate that there have been 17 occasions, other than hurricane experiences, during the period July 1938 through December 1960, when storms or other meteorologic conditions caused the tide at New London to reach an elevation of 4.2 feet, m.s.l., or higher. This elevation is approximately 1.9 feet above the level that would be reached in a high gravitational spring tide. The five highest tides so experienced at New London during this 22.5-year period are tabulated below:

<u>Date</u>	<u>Tide (ft., m.s.l.)</u>
25 November 1950	6.7
7 November 1953	5.9
19 February 1960	5.0
12 November 1947	4.9
3 March 1942	4.7

A-2. SUMMARY OF HURRICANES

A total of 69 hurricanes which are known to have either hit or narrowly missed the Connecticut coast is summarized in Table A-1. These hurricanes have been classified to indicate their magnitude along the Connecticut coast as follows:

Type "A": Hurricanes causing severe tidal flooding.

Type "B": Hurricanes causing damage from wind and rainfall

(usually accompanied by high seas and moderate tidal flooding).

Type "C": Hurricanes threatening the area.

Of the 69 hurricanes, 13 are of type "A", 24 of type "B", and 32 of type "C". Forty-three of the listed hurricane experiences have occurred during the period from 1901 to 1961. The fact that there is a record of 43 hurricanes in this 60-year period, as compared with 26 in the 266-year

period from 1635 to 1900, is believed to be due to lack of records and information on storms prior to 1900 rather than a trend toward increased hurricane activity in recent years.

TABLE A-1

HISTORICAL HURRICANES

CONNECTICUT COAST

<u>Date of Hurricane</u>	<u>Category</u> (1)	<u>Source of Data</u>	<u>Remarks</u>
1635, Aug. 15	A	(2)(3)	Great tidal surge along coast of R.I. Records do not indicate effect on Conn. coast
1638, Aug. 3	A	(3)	Historical account indicates greatest tidal flooding ever experienced along Mass. and R.I. coast. Records do not indicate effect on Conn. coast.
1723, Oct. 30	A	(3)	Very high tides in R.I.; considerable damage. Records do not indicate effect on Conn. coast.
1757, June 30 .	C	(2)	Atlantic coast hurricane, Florida to Boston, Mass. Records do not indicate effect on Conn. coast.
1761, Oct. 24	A	(3)	Very high tides in Narragansett Bay, R.I. Damage from wind and water. Records do not indicate effect on Conn. Coast.
1770, Oct. 19-20	A	(3)	A violent storm; immense loss of life and property along the coast. Report of boat damage at New London, Conn.
(Footnotes are at end of Table)			

TABLE A-1 (continued)
HISTORICAL HURRICANES
CONNECTICUT COAST

<u>Date of Hurricane</u>	<u>Category</u>	(1) <u>Source of Data</u>	<u>Remarks</u>
1773, Aug. 19	C	(2)(3)	Passed near Boston, Mass. "Abundant showers" in Conn.
1787, Sept. 19	B	(3)	Reports of damage at Stamford and Norwalk, Conn.
1788, Aug. 19	B	(2)(3)	Affected western New England much wind and rain damage in Conn. and western Mass.
1804, Sept. 8-9	C	(2)	Severe storm; passed over Cape Cod, travelling northeast. No account of damage in Conn.
1804, Oct. 9-10	B	(2)(3)	Reports of wind and rain damage.
1815, Sept. 22-23	A	(2)(3)(5)	Severe damage along Conn. coast from tidal flooding.
1821, Sept. 3	A	(2)(3)	Wind damage to boats and homes. Tidal flood damage at New London Conn.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

<u>Date of Hurricane</u>	<u>Category</u> (1)	<u>Source of Data</u>	<u>Remarks</u>
1829, July 24	C	(2) (3)	Reported to have been felt in Boston, Mass. No accounts of damage in Conn.
1841, Oct. 2-4	B	(2) (3)	Violent winds and heavy rain; reports of wind damage at Hartford, Conn.
1854, Sept. 10-11	C	(2) (3)	Severe in southern states; passed over New England, near Boston. Described as "an old fashioned rain-storm."
1866, Oct. 29-30	B	(2) (3)	Reports of wind damage.
1869, Sept. 8	A	(2) (3)	Tidal flooding at Mystic, Conn.
1877, Oct. 4-5	C	(2) (3)	Path was south of Long Island and Nantucket. No accounts of damage in Conn.
1878, Oct. 22-23	A	(2) (3)	Reports of wind damage and very high tides along Conn. coast.
1878, Dec. 10	B	(3)	Reports of wind, rain, and minor tidal-flooding along the coast.
1879, Aug. 18	B	(2) (3)	Passed over Cape Cod. Damage from wind and rain along Conn. coast
1889, Sept. 10	B	(2) (3)	Streets in Stamford flooded by heavy rain. Very high tide at Greenwich, Conn. Minor damage due to waves at Mystic.

TABLE A-1 (Continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

<u>Date of Hurricane</u>	<u>Category</u> ⁽¹⁾	<u>Source of Data</u>	<u>Remarks</u>
1893, Aug. 23-24	A	(2) (3)	Wind, rain, and high tide caused damage along Conn. coast.
1893, Aug. 29	B	(2) (3)	Storm passed west of New York city, crossed central Maine moving northeast. Reports of high tides and heavy surf along Conn. coast.
1896, Sept. 9-10	B	(2) (3)	Strong winds and heavy rains along Conn. coast.
1901, Sept. 19	C	(2) (4)	Passed south and east of Cape Cod.
1902, June 16-17	C	(2)(3)(4)	Path crossed Buzzards Bay and Cape Cod, moving northeast. Strong winds over L.I. Sound.
1902, June 29-30	C	(2)	Center passed over Conn. and southern R.I. traveling southeast; no account of damage.
1902, Oct. 12	C	(2)(3)(4)	Path south of Long Island and Nantucket, moving east. Heavy rain and high wind at New Haven, Conn. but no accounts of any damage along the Conn. coast.
1903, Sept. 16	B	(2) (3)	Storm crossed northeastern Pa., moving northwest. High winds and high water along Conn. coast.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

<u>Date of Hurricane</u>	<u>Category</u> (1)	<u>Source of Data</u>	<u>Remarks</u>
1904, Sept. 15	B	(2)(3)	Center passed over north-eastern Conn., moving northeast. Reports of rain and wind damage and heavy surf.
1904, Nov. 13	B	(2)(4)	Passed south of Nantucket, moving northeast. Reports of wind damage.
1911, Sept. 1	C	(2)	Passed south of Cape Cod. No accounts of damage in Connecticut.
1912, Sept. 16	C	(2)	Followed easterly path across southern New England.
1916, July 21	C	(2)(4)	Passed off east end of Cape Cod heading northeast. Reports of wind and rain damage in Connecticut.
1920, Sept. 30	B	(2)(3)(4)	Storm passed just west of New York, heading north. Reports of damage from high tides along Conn. coast.
1923, Oct. 19	C	(2)(4)	Passed near Boston, moving northwest. Storm of slight energy.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

<u>Date of Hurricane</u>	(1) <u>Category</u>	<u>Source of Data</u>	<u>Remarks</u>
1924, Aug. 26	B	(2)(3)	Crossed tip of Cape Cod, moving northeast. Some damage from strong winds.
1929, Oct. 2	B	(2)(4)	Moved northeast, passing over eastern New York and northwestern Vermont. High tides caused damage along Connecticut coast.
1933, Aug. 23-24	B	(2)(3)(4)	Driving rain and high tides along Conn. coast.
1933, Sept. 16-17	C	(2)(3)	Passed south of Cape Cod, moving northeast. No reports of damage in Conn.
1934, June 19	C	(2)	Travelled overland from Louisiana; crossed Long Island and Cape Cod, moving northeast.
1934, Sept. 9	B	(2)(4)	Crossed Long Island and central Conn. moving north. Wind damage along Conn. coast.
1936, Sept. 19	B	(2)(3)(4)	Passed south of Nantucket heading northeast. Wind damage along Conn. coast.
1938, Sept. 21	A	(2)(3)(4)	Most damaging storm to strike southern New England. Tidal-flooding along entire Conn. coast. 9-foot surge at New London.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

<u>Date of Hurricane</u>	<u>Category</u> (1)	<u>Source of Data</u>	<u>Remarks</u>
1940, Sept. 2	C	(2) (4)	Passed south of Nantucket, heading northeast. No accounts of damage in Conn.
1940, Sept 16	C	(2) (4)	Followed northeasterly path east of Cape Cod. No accounts of damage.
1943, Oct. 17	C	(2) (4)	Passed east of Cape Cod, moving due north. No accounts of damage.
1944, Aug. 3	C	(2) (4)	Moved northeasterly along path south of Long Island and Nantucket. No accounts of damage.
1944, Sept. 14-15	A	(2) (3) (4)	Center passed over Providence, R.I. and south of Boston, Mass. Tidal-flooding along entire Conn. coast; 6.2 feet, msl New London.
1944, Oct. 21	C	(2) (4)	Path crossed over Nantucket and easterly tip of Cape Cod. No accounts of damage.
1945, June 26	C	(2) (4)	Followed northeasterly path from Florida to Nova Scotia, passing south of Nantucket.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

<u>Date of Hurricane</u>	(1) <u>Category</u>	<u>Source of Data</u>	<u>Remarks</u>
1945, Sept. 19	C	(2)(4)	Overland from Florida; passed just west of New York, moving northeast.
1949, Aug. 29	C	(2)(3)(4)	Travelled overland from northern Florida, crossed center of Maine. High winds at Greenwich, Conn.
1950, Aug. 20	C	(2)(3)(4)	Passed south of Nantucket, heading generally northeast. Heavy rain at Greenwich, Conn.
1950, Sept. 11	C	(2)(3)(4)	Passed south and east of Nantucket, then headed east. No reports of damage in Conn.
1952, Sept. 1 ("Able")	C	(2)(3)(4)	Followed northeasterly track, approximately over New York. Heavy rain and high wind at Greenwich, Conn.
1953, Aug. 15 ("Barbara")	C	(2)(3)(4)	Followed path south of Long Island and Nantucket.
1953, Sept. 7 ("Carol")	C	(2)(3)(4)	Passed east of Cape Cod heading generally north.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

<u>Date of Hurricane</u>	<u>Category</u> (1)	<u>Source of Data</u>	<u>Remarks</u>
1954, Aug. 31 ("Carol")	A	(2)(3)(4)	Second most damaging storm to hit Conn. coast. Crossed east end of Long Island moving north; 8.9 feet, m.s.l. at New London.
1954, Sept. 11 ("Edna")	B	(2)(3)(4)	Passed over Cape Cod, heading north-east. High seas, minor damage from wind.
1954, Oct. 15 ("Hazel")	B	(2)(3)(4)	Moderate to heavy rains in New England. Peak gusts reached gale and whole gale force.
1955, Aug. 11 ("Connie")	C	(3)(4)	Caused scare in New England and heavy rainfall but no damage. Storm passed southwest of Washington, D. C.
1955, Aug. 18 ("Diane")	B	(2)(3)(4)	Passed just south of Long Island and about over Nantucket. Brought record rainfall to many areas of Conn.; heavy flood damage in river valleys; no important tidal-flood damage along coast.
1955, Sept. 19 ("Ione")	C	(3)(4)	Caused scare in New England but no reported damage. Storm turned east and then northeast after passing inland of Cape Hatteras.
1958, Aug. 25 ("Daisy")	C	(3)(4)	Caused scare in New England but no damage. South of Nantucket Island the storm turned east and then northeasterly.
1960, July 30 ("Brenda")	B	(3)(4)	Storm center crossed New England coast just west of Bridgeport, Connecticut, and continued into western Connecticut and western Massachusetts. Small boat damage and minor tidal flooding.
1960, Sept. 12 ("Donna")	B	(3)(4)	Storm center crossed New England coast near New London, Conn., continued over Worcester, Mass., and into New Hampshire. High winds and tides 4 to 5 feet above normal along southern coast of New England caused moderate tidal flood damage.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

NOTES

- (1) The following assigned categories pertain to the effect of a hurricane on the coast of Connecticut.
 - A: Caused severe tidal flooding.
 - B: Caused damage from wind and rainfall
(usually accompanied by high seas and moderate tidal flooding).
 - C: Threatened the area.
- (2) "Hurricanes - Their Nature and History," by I. R. Tannehill (1956).
- (3) Local newspaper accounts, histories, etc.
- (4) Material furnished by U. S. Weather Bureau.
- (5) Information furnished at public hearing at Pawcatuck, Conn.

TABLE A-2

SUMMARY OF OTHER NOTABLE STORMS THAT CAUSED HIGH TIDES
ALONG THE CONNECTICUT COAST

<u>Date of Storm</u>	<u>Remarks</u>
1639, March 16	"There was so violent a wind at south-southeast and south as the like was not since we came into this land. It began in the evening, and increased till midnight. It overturned some new strong houses; . . . It tare down fences - people ran out of the houses in the night, . . . There came such a rain withal, as raised the waters at Connecticut 20 feet above their meadows, etc. (Winthrop's Journal "History of New England, 1630-1649".)
1767, Jan. 12	"A great variety of articles have been found on the north side of Long Island supposed to have drifted from this colony (New London), in the late great freshet, among which are boats, timber, parts of houses, stacks of hay, etc." (The Massachusetts Gazette and Boston Weekly News-Letter.)

TABLE A-2 (continued)

SUMMARY OF OTHER NOTABLE STORMS THAT CAUSED HIGH TIDES
ALONG THE CONNECTICUT COAST

<u>Date of Storm</u>	<u>Remarks</u>
1767, Dec. 14	"From the southward we hear, that the gales . . . did considerable damage to the wharves and shipping at Newport, Stonington, New London, etc. The tides rose higher than had been known for many years in those places. . . Eleven sail bound up the sound were drove ashore at Stonington . . . It is said, the wind, which was at west-southwest was the most violent ever known along that coast." (The Massachusetts Gazette and Boston Weekly News-Letter, No. 3351.)
1771, Feb. 9	"Last Saturday morning came on a storm of snow and hail, which soon changed to rain, and the wind varying to the southeast brought into the harbor (New Haven) the fullest tide ever known, which ebbed and flowed two or three feet in a few minutes; and at the time it was expected to be low water, the tide was above high water mark. Great quantities of lumber were floated from the wharves, and a great deal of sugar, salt, etc. destroyed. A Brig and two sloops were drove ashore in the harbor". (The Massachusetts Gazette and Boston Weekly News-Letter, No. 3513.

TABLE A-2 (continued)

SUMMARY OF OTHER NOTABLE STORMS THAT CAUSED HIGH TIDES
ALONG THE CONNECTICUT COAST

<u>Date of Storm</u>	<u>Remarks</u>
1869, Oct. 3	"A fearful gale prevailed all yesterday along the Atlantic border and even carried its disastrous effects far into the interior. The rain fell in torrents, and great damages by floods are reported from every quarter." (Norwich Morning Bulletin.)
1895, Feb 7	"During the gale and high tide here (Stonington) Friday . . . The water flooded the engine room of the Atwood Machine Company. This is something that was never known to happen before. The damage at Eastern Point is more extensive than was first thought. People at the Point say they never before experienced such gales and such tremendous seas. The wharves will all have to be repaired. Some of the dwelling houses too present a very bedrabbled appearance." (The Day, New London, Conn.)
1896, Feb. 9-10	"The worst northeast storm of the season . . . has raged here (New London) all day. The surf is higher than it has been since the spring storms . . . The rainfall from its commencement Thursday up to 3:00 today (Friday) amounted to 5.16 inches and at that time was falling at

TABLE A-2 (continued)

SUMMARY OF OTHER NOTABLE STORMS THAT CAUSED HIGH TIDES
ALONG THE CONNECTICUT COAST

<u>Date of Storm</u>	<u>Remarks</u>
	the rate of three fourths of an inch an hour . . . The usual channels towards the river in all parts of the city have been overtaxed causing the water to set back and overflow the roads, meadows, yards, etc. and converting many of the cellars into lakes. From Bloom- ingdale back for a long distance the country is flooded and the roads covered with water to a depth of a foot in many places." (The Day, New London, Connecticut)
1942, March 3	Tide rose to 4.7 feet above mean sea level at New London, Conn.
1942, Dec. 2	Tide rose to 4.4 feet above mean sea level at New London, Conn.
1944, Nov. 30	Tide rose to 4.6 feet above mean sea level at New London, Conn.
1947, Nov. 12	Tide rose to 4.9 feet above mean sea level at New London, Conn.
1950, Nov. 25	Tide rose to 6.7 feet above mean sea level at New London, Conn.
1951, Nov. 3	Tide rose to 4.3 feet above mean sea level at New London, Conn.
1953, Nov. 7	Tide rose to 5.9 feet above mean sea level at New London, Conn.
1956, Mar. 16	" Tides reminiscent of those during all hurricanes ran abnormally high at Jupiter Point and Groton Long Point". (The Day, New London.). The tide at New London rose to 4.5 feet above msl.

TABLE A-2 (continued)

SUMMARY OF OTHER NOTABLE STORMS THAT CAUSED HIGH TIDES
ALONG THE CONNECTICUT COAST

<u>Date of Storm</u>	<u>Remarks</u>
1958, 16 Feb.	Tide rose to 4.6 feet above mean sea level at New London, Conn.
1958, 20 March	Tide rose to 4.5 feet above mean sea level at New London, Conn.
1960, 14 Feb.	Tide rose to 4.4 feet above mean sea level at New London, Conn.
1960, 19 Feb.	Tide rose to 5.0 feet above mean sea level at New London, Conn.

A-3. DESCRIPTIONS

Brief descriptions of type "A" and "B" hurricanes as reported in newspaper accounts or other records up to 1930 are given below. Subsequent to 1930 numerous and more adequate records are available of storm occurrences, including data on tidal-flood levels, wind velocities, and other storm characteristics.

a. 15 August 1635. From: "Of Plymouth Plantation, 1620-1647," by William Bradford.

"This year the 14 or 15 of August (being Saturday) was such a mighty storm of wind and rain, as none living in these parts either English or Indian, ever saw, being like (for the time it continued) to those Hauricanes and Tuffons that writers make mention of in the Indies. It began in the morning, a little before day, and grew not by degrees, but came with violence in the beginning to the great amazement of many. It blew down sundry 211 houses, and uncovered others; divers vessels were lost at sea, and more in danger. It caused the sea to swell (to southward of this place) about 20 feet, right up and down, and made many of the Indians to climb into trees for their safety; it took off the board roof of a house which belonged to this plantation at Manamet, and floated it to another place, the posts still standing in the ground; and if it had continued long without the shifting of the wind, it is like it would have drowned some part of the country. It blew down many hundred thousands of trees, turning up the stronger by the roots, and breaking the higher pine trees off in the middle, and the tall young oaks and walnut trees of good bigness were wound like a withe, very strange and fearful to behold. It began in the southeast and parted toward the south and east, and veered sundry ways; but the greatest force of it here was from the former quarters. It continued not (in the

extreme) above 5 or 6 hours, but the violence began to abate. The signs and marks of it will remain this 100 years in these parts where it was sorest. The moon suffered a great eclipse in the second night after it."

From: "The History of New England from 1630 to 1649," by John Winthrop.

"... This tempest was not so far as Cape Sable, but to the south more violent, and made a double tide all that coast

"The tide rose at Narragansett fourteen feet higher than ordinary and drowned 8 Indians flying from their wigwams."

b. 3 August 1638. From: "The History of New England from 1630 to 1649", by John Winthrop.

"In the night was a very great tempest or hiracano at Southwest which drove a ship on ground at Charlestown, and brake down the windmill there, and did much other damage. It flowed twice in 6 hours, and about Narragansett it raised the tide 14 to 15 feet above the ordinary spring tides, upright."

c. 30 October 1723. From: "The Boston News-Letter, No. 1032. Thursday October 31 to Thursday November 7, 1723."

"Rhode Island, November 1

"... On Wednesday last we had here a very great Southeast storm of wind and rain, and a very high tide, a foot higher than ever was known before, which has broken and carried away several of our wharves, and drove some vessels ashore from their anchors, and has done considerable damage in warehouses and cellars, to dry goods and other merchandise; the loss is computed to some thousand pounds."

d. 24 October 1761. From: "The Boston News-Letter No. 2991. Thursday, October 29, 1761."

"There was a hard gale of wind which brought the highest tide into the harbor of Providence in Rhode Island that hath been known in the memory of man, and carried away the great or Weybosset Bridge. Five or six vessels were drove ashore and greatly damaged, and it being high water there, it got into the stores and cellars and damaged sugars, etc. to the amount

of 12 or 15000 pounds their currency. On both roads East and West, so far as we have heard, the roofs of houses, tops of barns and fences, have been blown down, and it is said thousands of trees have been torn up by the roots by the violence of the above storm, and we fear we shall hear melancholy accounts of damage done at sea."

From: "Memoirs of Rhode Island 1636-1783", by Henry Bull.

"From the Newport Mercury of October 27, 1761 - On Friday last came on a terrible storm from the Northeast, which continued increasing with a very heavy rain, and did not abate till after 2 in the morning. The violence of the wind broke off part of the steeple of the Trinity Church. Several persons sustained considerable loss in their sugar, salt, etc. by the prodigious rise of tide, which flowed into their stores and cellars. Many of the ships in the harbor were driven ashore from the wharves and their moorings, but without any considerable damage except to two ships. Sad havoc has been made with the lumber and wood on the wharves, great quantities of fence blown down and numbers of trees torn up by the roots. People hardly thought themselves safe in their own houses, for a more violent storm has scarce ever been known here."

e. 19-20 October 1770. (Type "A") "History of the State of Rhode Island", by Samuel Greene Arnold.

"A violent storm again blew down a part of the spire of Trinity Church at Newport and caused an immense loss of life and property along the coast. Newport suffered very severely in this gale."

From: "The Connecticut Journal", November 21, 1770.

"New London, Oct. 26

"On Friday Night and part of the next day we had a very severe Storm of Wind and Rain from the N.E. by which two Vessels were drove ashore in this Harbor but received little or no damage."

f. 19 September 1787. (Type "B"). From the diary of William Wheeler in "Black Rock, Seaport of Old Fairfield, Connecticut 1699-1870."

"Line storm. A mill at Stamford carried off whole and Norwalk bridge floted."

g. 19 August 1788. (Type "B") From the diary of William Wheeler in "Black Rock, Seaport of Old Fairfield, Connecticut 1699-1870."

"The hardest gale that has been for many years -- at 1 o'clock a Sloop and Schooner went on shore---. The Gale reached 100 miles up country, in some places shifting from SE to NW & twisting of trees 9 inches in diameter--it moved Carson's house about 6 feet."

From: "The New-Haven Gazette and the Connecticut Magazine," Thursday, August 21, 1788.

"New Haven.

"Last Tuesday morning came on a violent gale of wind from the South, which at about one o'clock, P.M. veered to S.S.W. and blew a perfect hurricane.

"Several vessels were driven ashore and very material damage is done to the long Wharf---We expect to hear of much damage done at sea and in the harbours on our coast..."

From: "The Connecticut Courant and Weekly Intelligence," Monday, August 25, 1788.

"New Haven, Aug. 20.

"Yesterday we had a violent gale of wind, the height of which was from the S.E. about one o'clock. Though the tide was not full as has been frequent in easterly storms, considerable damage was done to the Long-Wharf by the violence of the waves and several vessels parted their masts, but the shipping received no material damage. The Indian corn is much injured and the trees stripped of their fruit and some apple trees blown down."

h. 9-10 October 1804. (Type "B"). From: "The Connecticut Courant," (October 17).

"The partial and summary accounts which have been received from the neighboring towns, though they afford no particulars of the effects of the late gale, sufficiently evince the widespread destruction which has been experienced by it. In all most every direction the

fruit and other trees have been generally blown down, the fences destroyed and much damage done by the heavy rain, which fell during the storm."

i. 22-23 September 1815. (Type "A"). From: "Connecticut Herald," (New Haven) September 26.

"The storm. -- On Friday night and Saturday morning last a severe storm of wind and rain was experienced in this vicinity...The most material injury sustained here was to Long Wharf, which was entirely inundated by the highest tide known for a great number of years. Everything movable on the wharf was swept away. The water in some of the stores was nearly two feet deep, but no great loss of property took place except in a quantity of rum which was swept from the wharf, several hoghead of which have not yet been recovered..."

From: "The Connecticut Courant," October 4.

"Bridgeport, Sept. 27.

"The late Storm which commenced on Thursday last continued with increasing violence until 11 o'clock on Saturday morning. The wind during the whole time blew a severe gale accompanied with rain from the N.E. and had so much increased the waters in the Sound that the tide, which in ordinary weather would have been full at 2 o'clock and 44 minutes, attained its greatest height at 12 o'clock 30 minutes, and was then near six feet above common flood tides; and had it not fortunately happened that the wind some hours before the tide was at full veered round to the N.W. it must have risen to an alarming height. The oldest inhabitants do not remember so high a tide by nearly one foot. The water through the whole length of Water Street was of sufficient depth for the largest long boat to pass loaded with passengers. Considerable damage has been sustained in the stores along the shore by the destruction of salt, grain and other bulky articles that could not speedily be removed.

From: "Norwich Courier", September 27, 1815.

"Norwich.

"

"The damage done in this town and neighborhood by the violence of the wind and the extraordinary rise of the tide, is great beyond precedent. Scarcely a store on the wharves has escaped injury - some of them have been entirely swept away - and goods to a considerable amount damaged or destroyed. The water on the wharves and the Lower Street was 4 feet higher than can be remembered on any former occasion The water beat over the wharf bridge with incredible force. Its depth there was at least 6 feet; and such was the fury from the action of the wind, that the market and a store adjoining were carried away. Immense numbers of trees, of every description, were levelled to the earth - As also fences in all direction.

"NEW LONDON.

"The effects of the gale within New London we understand were very much more severe than at this place. The wharves were ruined, and the shipping has suffered dreadfully. Many of the buildings on Beach Street are swept away - others unroofed - and fences and trees blown down in every direction."

"STONINGTON

"The tempest rages with extreme violence. A number of vessels bound to the eastward had put in here for a harbor, every one of which was driven on shore."

j. 2-3 September 1821. (Type "A") From: "Connecticut Herald," (New Haven), Tuesday, September 11.

"We were visited in the evening of the 3d inst. by a toronado almost unexampled in this latitude. The gale commenced at S.E. about 6 o'clock but was most violent from 8-10, the wind then varying from S.S.E. to S.W.--nearly all the vessels in the harbor were driven by the force of the storm, and are more or less damaged... Fortunately at the height of the gale, it was time of low water; otherwise,

damage to shipping, wharves, stores &c, must have been incalculable...The rafters and gable end of a brock store on the wharf...were blown down...part of the roof of Mr. Thomas Hunt's dwelling in Water St. was torn off...scarcely a street was exempted from fallen chimnies and fences. Several trees were upturned by the roots...the leaves of most of which remain are changed to a singular dark brown hue.

"Part of the first bridge on the pier was carried away by the driving of a sloop, who struck upon her stem.

"At Bridgeport, several buildings were blown down or unroofed..Almost all the vessels in port were driven ashore, but without much injury.

* * *

"New London, September 5.

"Severe Gale. --On Monday night last we experienced a severe gale from the South-East. It commenced about 7 in the evening, and lasted until midnight. The tide rose several feet above its ordinary level and some damage was done to our wharves and boats..."

From: "Black Rock, Seaport of Old Fairfield, Connecticut, 1699-1870."

"A tremendous gale of wind E & SE from 6 to 11 in the evening passed over this place--torn down many...trees...every vessel went ashore in this harbor--a sloop dismasted in the sound and the lighthouse laid flat. The hardest gale ever remembered.

"The leaves of the trees as in 1788 are turned brown..small limbs of trees blew thirty rods--there was a continual roaring like thunder..."

k. 4 October 1841. (Type "B"). From: "Hartford Daily Courant,"
Tuesday, October 5.

"Severe Storm--We have been visited by a most remarkable storm--the like of which, so early in the season, on account of its severity and continuance, is not remembered by our oldest inhabitants. On Saturday night it

commenced raining, the wind from the northeast, and continued without intermission, intermingled a part of the time with snow and accompanied by wind until sometime yesterday afternoon. During a part of Sunday night, the wind blew a perfect hurricane, and the rain came down in torrents...Many valuable fruit and ornamental trees have been prostrated or stripped of their limbs... as the storm undoubtedly extended along the coast, we may expect to hear of damage from that quarter."

1. 29-30 October 1866. (Type "B"). From: "Hartford Daily Courant," October 31.

"One of the hardest storms of the season prevailed on Monday and continued through yesterday. It was a regular southeaster--one of those violent storms that often haunt us at this season of the year--The wind prostrated the lines between New Haven and New York and at other places east and south. The steamer Granite State left New York at the usual hour on Monday and met with rough weather on the Sound..."

m. 8 September 1869. (Type "A"). From: "Norwich Morning Bulletin," September 12, 1869.

"Storm (at Mystic, Conn.) worst since 1815. Came at low water and the tide, though rising higher than it has for 2 or 3 years, did less damage than it otherwise would have done. Had it occurred at highwater, the bridge and a large part of Mystic would have been submerged. The tide rose at the rate of an inch a minute, walling up a foot high where it struck the spiles at the bridge."

n. 23 October 1878. (Type "A"). From: "The Daily Standard", Bridgeport, October 23, 1878.

"A section of the fence...opposite the depot blew down this morning.

"A portion of the bulletin board corner High and Main Streets blew down this morning. Limbs were broken off the trees in all sections of the city.

"The storm last night and this morning drove a number of small boats ashore below the Naugatuck dock and their owners turned out and dragged them beyond reach of the waves..."

"The sea held high carnival at Sea Side Park this morning, and a wilderness of rolling white caps and tempest of dashing spray bore witness to the disturbed mood of the waters, angered by the howling winds..."

From: "Greenwich Observer," October 24, 1878.

"....The storm yesterday was very severe and the shipping in our harbor was roughly tossed. The tide rose to a remarkable degree..."

From: "The Daily Standard," Bridgeport, October 24, 1878.

"New Haven, Oct. 23d,--The steamer John Bramhall, Captain Pollard, from this city, ashore on Little Cull Island, has gone to pieces in the gale."

^{o.}
(Weekly) 18 August 1879. (Type "B"). From: "Stamford Herald,"
August 20.

"---From a test made at Waterside the rainfall during the late storm was found to be 8 inches. On Monday from 7 a.m. to 7 p.m. a little over $4\frac{1}{2}$ inches fell.

"A more soaking continuous and persistent rainstorm we have seldom experienced in August... corn has suffered under the infliction of so much rain and wind..."

^{p.}
Friday, 10 September 1889. (Type "A"). From: "The Greenwich News,"
September 13.

"The furious northeaster which has been raging along the Atlantic Coast for the past few days is one of the severest storms known in this vicinity for years, and one of the most destructive to property. Ever since Tuesday when the storm reached here from the Atlantic, it has blown a gale, mostly from the northeast, accompanied nearly all of the time by rain.

"The greatest force of the storm has been felt along the coastline...small craft along the shore have suffered severely..."

"Greenwich has suffered comparatively little from the storm. A few tress have been blown down and the roads have been damaged more or less, but beyond this there was scarcely any damage done. On Tuesday there was a very high tide in the harbor and at one time part of the steamboat dock was under water...the only loss reported along the shore are one or two row boats."

"The schooner Annie Jacobs from New Haven...was beached on Mansuring Island during the storm Tuesday night."

From: "The Westerly Narragansett Weekly", September 19.

"The high surf last week drew crowds of sight-seers to Watch Hill from Westerly, Stonington and Mystic. It was a grand sight to see the big waves come rolling in, until apparently they were about to swamp the land. Not much damage was done except the destruction of the Peninsula house"

g. 23-24 August 1893. (Type "A") From: "Stamford Advocate," August 24.

"One of the most severe storms of wind and rain ever experienced in this locality started last night and continued increasing in force until this forenoon. The evidence of its severity were to be seen on every hand . . streets washed out and flooded, buildings damaged . . .

" . . . Every boat in the harbor was adrift . . . The tide rose higher than has ever known for some time. All the streets in the vicinity of Waterside were impassable, the water coming up over the meadows to the foot of Atlantic Street . . .

"The scene in the lower harbor at high tide this morning was a wild one . . . On the whole the craft in the lower harbor escaped well, much better probably than they would have done had a gale of equal force come in from the southwest."

r. 29 August 1893. (Type "A") From: "The Columbian Weekly Register," (New Haven), Thursday, August 31.

"Early this morning the wind blew 50 miles an hour, breaking all previous records . . . Late last night the barometer recorded 29.98, but it was only 29.38 early this morning . . .

"The waves swept in with terrible fury all along Savin Rock shore. They had full play at the docks made of logs and boards and stone. When the tide was high, about 8 o'clock, the water came up over Beach Street and threatened to enter the handsome shore cottages that front the harbor from Skeele's pavilion to O'Connell's hotel on the Rock . . . mud from the street was picked up by the spray and spattered on the windows. .

"The waves leaped into the air 20 or 30 feet at a time . . .

"The waves were . . . tumbling upon the street in front of the Surf House and were making their way into the ground floor of the hotel. The tide was at its height and soon after began to recede; with the falling of the tide the danger that threatened the house in being overflowed with a part of Long Island Sound subsided . . . The dock or wharf front of logs and boards was partially demolished. Mr. Cox's damage will be at least \$500.00...

"But the storm's destructive power was felt in dead earnest at Stewart's pavilion and thereabouts in front of Sea View hotel. The Sound took one bite out of the solid earth in front of Stewart's that was 75 feet long and 10 and 20 feet wide in some places...

"The wind was tearing over Savin Rock at a 60-mile gait."

From: "The Westerly Narragansett Weekly," August 31.

"Mystic.

"The storm did considerable damage. The schooner . . . broke loose from her bow fastening, drifted out lengthwise of the river, making a blockade. Telephone and telegraph lines are down. Numerous washouts occurred on railroad lines (in the area around Mystic)."

s. 9-10 September 1896. (Type "B") From: "Greenwich Graphic,"
September 25.

"Between five and six o'clock on Saturday night it rained and blew in a way that caused many people to be frightened. It was the most severe storm we have had this summer... From William St. to Putnam Ave. it was impassable after the storm.

The wind twisted the great trees and broke them as though they were pipe stems...The rain came down almost in torrents and on Greenwich Avenue the water flowed in the gutters like the stream from a large brook."

From: "The Day", Thursday, September 10.

"Groton.

"There is no doubt but what the wind could have blown harder than it did Wednesday night, but there is no one hereabouts but what is satisfied it blew hard enough. The twigs and branches of the trees that strew the streets this morning was evidence of its destructive power. No greater damage outside of the breaking of trees was reported."

t. 16 September 1903. (Type "A") From: "The Bridgeport Daily Standard," September 17.

"Very strong winds and rain unroofed houses, felled or uprooted trees.

"...a casual survey of the damage along the waterfront shows that it will run into the thousands...

"At the Bridgeport Yacht Club in the Black Rock harbor there was damage galore, and but for the active work of the yachtsmen there would have been several fine yachts totally wrecked.

"Although the waves were very high the water did comparatively little damage...no water ever reached the roadway although everybody was completely drenched with the spray which rose in a long continuous, heavy white cloud the whole length of the sea wall."

From: "The Westerly Daily Sun", September 17.

"New Haven

"Southwest Connecticut came within the radius of the storm which swept up the Atlantic coast and the fury of the elements did greater damage than any disturbance of a like character in the month of September for a great many years. Trees were ripped up, telephone and telegraph wires were torn down . . . At many places small craft were dashed to pieces on the shore. Crop damage was severe."

From: "The Daily Advocate," Stamford, September 16.

"The storm which is raging all over this section struck Stamford with a vengeance at noon today and inside of an hour it had shaped itself into what old-timers say, is the swiftest easterly storm experienced for twenty years or more...

"On the east shore of Shippan, the storm was felt with great severity, and the same is true of Sound Beach where there are a number of summer cottages near the shore.

"The wind blew great guns...rain fell in veritable sheets. On exposed corners this was particularly noticeable, the pavements being under a constant wash of water... The wind came from the east and blew at from 75 to 80 miles an hour."

u. 15 September 1904. (Type "B"). From: "New Haven Evening Register," September 15.

"At one time early this morning, shortly after midnight the wind being then at the southwest, blew at the rate of 40 miles an hour....During the entire progress of the storm in New Haven 3.96 inches of rain fell... At Casey Beach, during the early part of the storm, the shore was heavily lashed by angry waves and for a time it seemed as though some of the lighter of the houses would be thrown from their foundations. Then the wind shifted and blew offshore and the water smoothened...Trees were uprooted and oyster beds damaged by the winds..."

v. 9-14 November 1904. (Type "B") From: "New Haven Evening Register," November 14.

"Here in New Haven the wind in yesterday's gale blew as high as 50 miles an hour. Many telephone and telegram wires were prostrated and there was some light wreckage about the harbor..."

w. 1 October 1920. (Type "A"). From: "The Daily Advocate," Stamford, October 1.

"The wind attained a velocity of 60 miles an hour, and it roared along the shorefront in an alarming manner, but did no great actual damage there. It veered from south by east, late in the afternoon to a more

southerly direction as the night wore on. Its greatest velocity was attained about midnight. That was sufficient to rock some houses on their foundations.

"Boats were torn from their moorings and trees were blown down."

* * *

"Norwalk, Oct. 1. --Last night's storm here was the worst in years, doing damage along the Sound shore. The tide reached a record height at 1 a.m., the water covering the roads and wrecking a number of cottages at Belle Island ...12 small boats were carried ashore and wrecked...and much damage done by the wind."

"New Haven, Oct. 1. Thousands of dollars of damage was done along the Sound shore last night by one of the worst storms in several years. Driven by a gale which exceeded 40 miles from the southeast and accompanied by a high tide. The waves rolled mountain high against the beach during the night, the tide reaching a record height about midnight. Many boats were washed ashore, cottages, piers and breakwaters being partially wrecked.

"At the Weather Bureau this morning it was stated that the wind reached a velocity of 42 miles at the height of the storm. A total rainfall yesterday and last night of 2.51 inches was recorded."

From: "The Day," October 1.

"New London

"The gale which swept the east last night and early this morning did a large amount of damage in Connecticut, principally to telephone, telegraph and trolley systems, caused the wrecking of 3 barges near this city and brought loss to rural districts through the destruction of late crops and fruit.

"

"New London was visited by an unusually severe wind and rain storm Thursday. The storm which began early in the day developed into a gale Thursday night,

the wind blowing with a velocity of about 80 miles an hour when it reached its height about midnight. The damage was considerable but not serious. Telephone and electric wires were blown down, limbs were ripped off trees and in one or two instances trees were uprooted. Shipping on the Sound was delayed."

x. 26 August 1924. (Type "B"). From: "Stamford Sentinel", August 27.

"Nothing like the devastation of felled wires, cables and poles in the eastern part of the state ever has been experienced by the telephone people..."

* * *

"New Haven, Conn. Aug. 27. ---With approximately 6,000 telephones out of commission in the territory east of Saybrook, a section of the state severely hit by a juvenile tornado late yesterday afternoon the Southern New England Telephone Company suffered more damage than ...in a great many years..."

y. 3 October 1929. (Type "A") From: "New Haven Journal-Courier," October 3.

"Damage which will probably total thousands of dollars was done yesterday along west shore in Milford by the lashing northeaster which swept northward from the Caribbean..its ferocity had been largely spent by the time it had reached the shores of Long Island Sound ...

"The largest damage reported from along the shore yesterday came from Silver Beach in Milford where the strong northeasterly and easterly gale created waves at the high tide hour this morning which tossed one cottage off its foundations..."

"The water overflowed the trolley tracks and in some places covered the Milford shore road to a depth of two feet...the storm concentrated its fury on the Milford shore ...

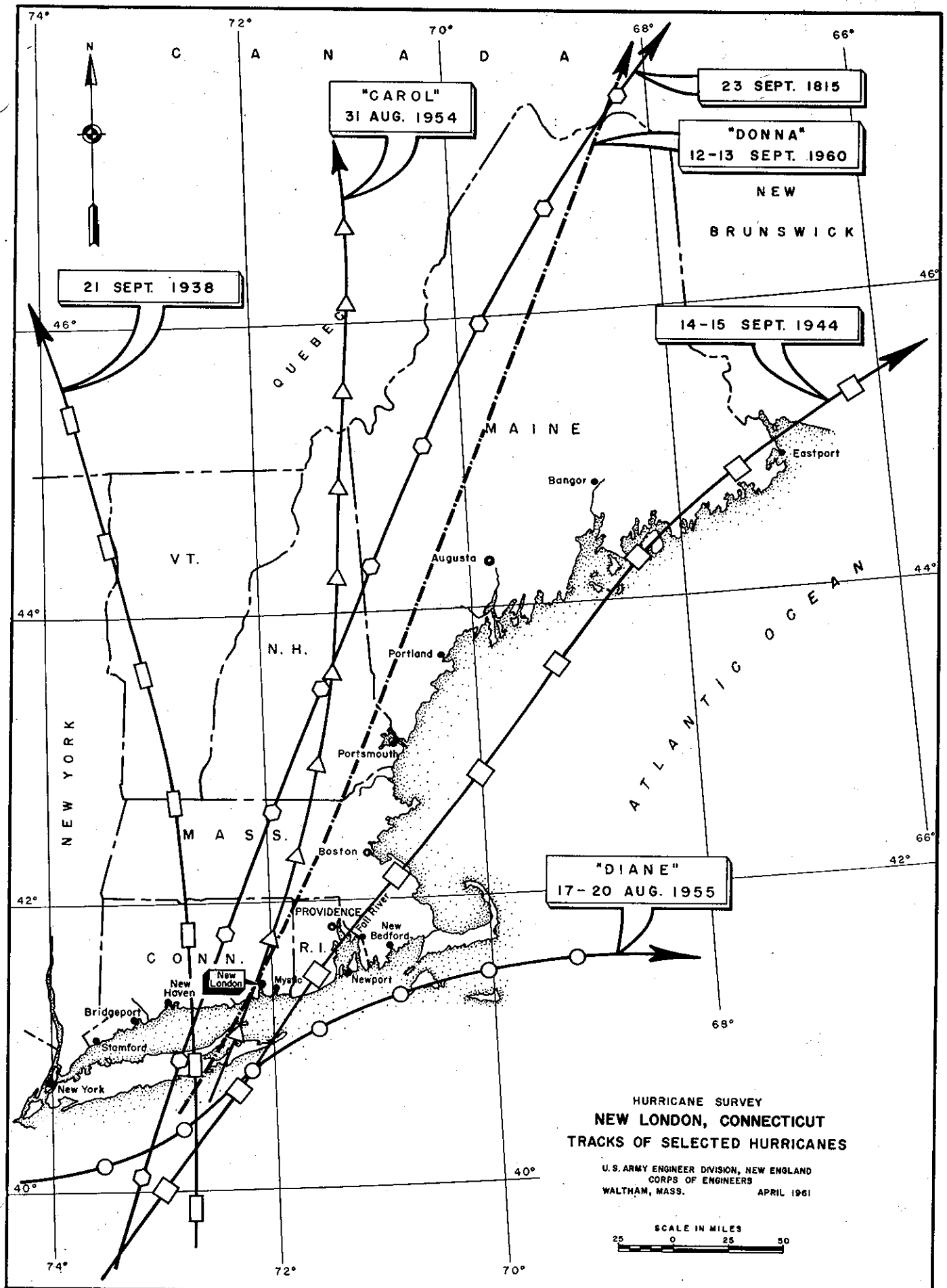
"High tides came near flooding street car tracks where they pass close to the water's edge on the shore runs, it was said, but no delays were brought about by this cause.

"Official figures...for total rainfall...of 2.03 inches between 8 p.m. and 8 a.m. yesterday and precipitation for the 12 hours after 8 a.m. yesterday being 1.30 inch.

"The wind velocity at both 8 a.m. and 8 p.m. was 12 miles per hour atop the post office building, but reports had velocities of 25 miles an hour at Milford."

A-4. HURRICANE TRACKS

The tracks of four notable hurricanes causing tidal flooding and serious damages along the Connecticut coast, namely, those of September 1815, September 1938, September 1944, and August 1954 are shown on Plate A-1. The path of Hurricane Donna, September 1960, the most recent hurricane to strike New England, and Hurricane Diane, August 1955, which brought record rainfall to many areas in southern New England, are also shown on the plate.



APPENDIX B
HYDROLOGY AND HYDRAULICS

APPENDIX B

APPENDIX B
HYDROLOGY AND HYDRAULICS

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APPENDIX B

HYDROLOGY AND HYDRAULICS

INTRODUCTION

B-1. This appendix presents data to supplement the sections of the main report relating to hydrology and hydraulics. It includes a summary of temperature and precipitation data to amplify the section of the report on "Climatology," and data on hurricane wind velocities, rainfall values, and barometric pressures to augment report material on the history and frequency of hurricanes. Computations of runup and ponding, determinations of tidal flood levels and design storm tide, detailed analyses of wave height, runup, overtopping, and current velocities are also included in this Appendix.

HYDROLOGY

B-2. TEMPERATURE AND PRECIPITATION

Significant temperature and precipitation data were taken from the United States Weather Bureau Station at New London, Connecticut. The monthly mean temperatures are based on the period of record from 1871 to 1954, while the maximum and minimum temperatures are based on the period 1885 to 1954. The monthly mean, maximum and minimum precipitation is based on an 84-year record (1871-1954). Tables B-1 and B-2 summarize the temperature and precipitation records.

TABLE B-1
MONTHLY TEMPERATURE
NEW LONDON, CONNECTICUT

<u>Degrees Fahrenheit</u>				<u>Degrees Fahrenheit</u>			
<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
Jan.	29.8	67	-7	July	71.7	99	44
Feb.	29.8	68	-17(1)	Aug.	70.3	100(2)	44
Mar.	37.4	84	3	Sept.	64.4	95	35
Apr.	46.9	91	13	Oct.	54.3	87	24
May	57.4	93	31	Nov.	43.4	77	9
June	66.2	97	38	Dec.	33.0	67	-12
				Annual	50.4		

(1) 9 Feb. 1934
(2) 26 Aug. 1948

TABLE B-2
MONTHLY PRECIPITATION
NEW LONDON, CONNECTICUT

<u>Inches</u>				<u>Inches</u>			
<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
Jan.	4.04	8.61	0.50	July	3.53	7.13	.44
Feb.	3.62	11.98	.43	Aug.	4.39	16.44(2)	.48
Mar.	4.20	10.96	.35	Sept.	3.41	11.21	.33
Apr.	3.76	10.85	.64	Oct.	3.52	8.47	.20
May	3.49	9.03	.54	Nov.	3.83	9.40	.32
June	3.09	7.71	.01(1)	Dec.	3.77	10.67	.73
				Annual	44.61	60.62(3)	30.05(4)

(1) 1949
(2) 1874
(3) 1919
(4) 1896

B-3. STREAMFLOW

The Thames River, a tidal estuary, extends about 15 miles northward from its mouth at New London to Norwich at the junction of the Yantic and ~~Quinebaug~~ ^{Shetucket} Rivers. The drainage area of the Thames River is approximately 1,473 square miles in eastern Connecticut, south central Massachusetts, and western Rhode Island. There are no streamflow records for the Thames River but there are gaging stations on its tributaries. The maximum flow recorded on the Quinebaug River at Jewett City, Conn., drainage area 711 sq.mi., was 40,700 cfs or 57.4 cfs per sq.mi. On the Yantic River at Yantic, Conn., drainage area 88.6 sq.mi., the maximum flow was 13,500 cfs or 152.5 cfs per sq.mi. during the hurricane of 1938. The Thames River, because of its width and tidal characteristics at New London, is not subject to flooding by river flows.

B-4. DRAINAGE AREAS

The drainage area behind the Shaw Cove Barrier is 865 acres with a maximum elevation of about 200 feet msl. The drainage area behind the Powder Island Barrier is 197 acres with a maximum elevation of about 130 feet msl. Large portions of these drainage areas include a paved street system with storm sewers.

B-5. HURRICANE RAINFALL

Among the greatest rainfalls associated with hurricanes in New England are those recorded for "Connie" and "Diane" in August 1955. Hurricane "Connie," 11-15 August, caused rainfall varying from about four to six inches over southern New England and ended a period of drought. A week later, 17-20 August, Hurricane "Diane" brought rainfall of 16 to 20 inches over Connecticut and Massachusetts. These hurricanes caused a total fall of 7.95 inches at Groton, and 5.8 inches at New London, Connecticut.

Excessive rainfall also was associated with the September 1938 hurricane. The maximum precipitation for the September 1938 storm was concentrated over Portland (Buck), Connecticut, about one mile north of Middletown, where a total of 17 inches was recorded for the period 17-21 September. However, at Kingston, Rhode Island, 30 miles northeast of New London, the total was 2.8 inches, and at New Haven, Connecticut, 45 miles west of New London, the total was 11.6 inches.

The rainfall in a number of recent hurricanes, recorded at the U.S. Weather Bureau Station at New London and four nearby stations is tabulated in Table B-3.

TABLE B-3

HURRICANE AND OTHER STORM RAINFALLVICINITY OF NEW LONDON, CONNECTICUTACCUMULATED RAINFALL IN INCHES

Hurricane or Other Storm	<u>Westbrook, Conn.</u>		<u>New London, Conn.</u>		<u>Groton, Conn.</u>		<u>Kingston, R.I.</u>		<u>New Haven, Conn.</u>	
	<u>Max. (1)</u>	<u>24-hr. Total</u>	<u>Max. (1)</u>	<u>24-hr. Total</u>	<u>Max. (1)</u>	<u>24-hr. Total</u>	<u>Max. (1)</u>	<u>24-hr. Total</u>	<u>Max. (1)</u>	<u>24-hr. Total</u>
Sept. 1938	-	-	-	-	-	-	1.3	2.8	6.4	11.6
Sept. 1944	2.8	6.2	3.4	7.1	-	-	2.4	4.4	4.0	8.5
Aug. 1954 (Carol)	4.4	4.4	4.5	5.0	3.4	3.5	2.9 ⁽¹⁾	2.9	2.75	2.75
Sept. 1954 (Edna)	5.6	5.6	4.0	5.3	6.2	6.2	5.5 ⁽¹⁾	5.5	5.55	5.55
Aug. 1955 (Connie)	4.3	7.3	2.0	4.0	5.1	5.6	5.3 ⁽¹⁾	5.7	3.2	3.6
Aug. 1955 (Diane)	1.4	2.2	1.8	1.8	1.2	2.3	2.2 ⁽¹⁾	3.2	3.2	4.3
Oct. 1955	-	5.1	-	-	2.3	4.3	3.1 ⁽¹⁾	4.65	3.8	5.9

(1) Non-recording station - values based on daily readings

B-6. HURRICANE WINDS

The most reliable data on experienced hurricane wind velocities in New England begin with the September 1938 hurricane. The maximum velocity recorded in New England during this storm was a gust of 186 m.p.h. at the Blue Hill Observatory in Milton, Massachusetts where a sustained 5-minute wind of 121 m.p.h. was also recorded. At other locations in southern New England, sustained 5-minute velocities ranging from 38 to 87 m.p.h. were experienced.

Sustained 5-minute velocities of from 33 to 85 m.p.h. were recorded at a number of locations along the New England coast during the hurricane of 14 September 1944.

In southern New England, during Hurricane "Carol" (31 August 1954), gusts of 125 and 135 m.p.h. were experienced at Blue Hill Observatory, Milton, Massachusetts and Block Island, Rhode Island, respectively. Sustained 1-minute velocities ranging from 38 to 98 m.p.h. were registered.

Wind velocities at locations in southern New England for the three great hurricanes of 1938, 1944, and 1954, are given in Table B-4.

B-7. HURRICANE BAROMETRIC PRESSURES

The center or "eye", of the 1938 hurricane entered Connecticut about 15 miles east of New Haven or about 30 miles west of New London at about 3:30 P.M., E.S.T., on 21 September and then proceeded northerly at a rate of 50 to 60 m.p.h. The lowest pressure registered during the passage of this storm was 28.04 inches at Hartford, Connecticut.

In the hurricane of 14 September 1944, the "eye" of the storm passed inland between Charlestown and Point Judith, Rhode Island, (25 miles east of New London) at 10:20 P.M., E.S.T. It then continued in a northeasterly direction, veering out to sea at Boston, Massachusetts. The minimum recorded barometric pressure in southern New England during this storm was 28.31 inches at Point Judith, Rhode Island.

The center of Hurricane "Carol" (31 August 1954) crossed the south shore of Connecticut in the vicinity of New London at about 10:30 A.M., E.S.T., and then followed a general northerly path across New England. The minimum barometric pressures in New England during this hurricane were 28.20 inches at Storrs, Connecticut, (35 miles northwest of New London) and 28.26 inches at New London.

The minimum pressures recorded at a number of New England locations during these three great hurricanes of the past 20 years are given in Table B-5.

TABLE B-4

WIND VELOCITIESHURRICANES OF 1938, 1944 and 1954 IN NEW ENGLAND

<u>Location</u>	<u>Velocity in Miles Per Hour</u>			<u>Direction</u>
	<u>Sustained 5-Min.</u>	<u>Sustained 1-Min.</u>	<u>Maximum Gust</u>	
<u>Hurricane of 21 September 1938</u>				
Hartford, Conn.	46	-	59	NE
New Haven, Conn.	38	-	46	NE
Providence, R.I.	87	95	125(est)	SW
Block Island, R.I.	82	-	91	SE
Milton, Mass. (Blue Hill Observatory)	121	-	186	S

<u>Hurricane of 14 September 1944</u>				
New Haven, Conn.	33	38	65	N to NE
Hartford, Conn.	50	62	109(est)	N
Block Island, R.I.	82	88	100+	SE
Chatham, Mass.	-	85	100(est)	-
Point Judith, R.I.	85(est)	90(est)	-	SSE
Milton, Mass. (Blue Hill Observatory)	67	77	-	-

<u>Hurricane of 31 August 1954, "Carol"</u>				
Bridgeport, Conn.	-	-	60	-
New Haven, Conn.	-	38	65	N
Hartford, Conn.	-	56	64	NE
Block Island, R.I.	-	98	135	SE
Milton, Mass. (Blue Hill Observatory)	-	93	125	SE

TABLE B-5

MINIMUM BAROMETRIC PRESSURESHURRICANES OF 1938, 1944 and 1954 IN NEW ENGLAND

<u>Location</u>	<u>Time</u> <u>EST</u>	<u>Barometer</u> <u>(inches)</u>
<u>Hurricane of 21 September 1938</u>		
Hartford, Conn.	4:17 P.M.	28.04
New Haven, Conn.	3:30 P.M.	28.11
Block Island, R.I.	3:05 P.M.	28.66
Milton, Mass. (Blue Hill Observatory)	--	29.01
<u>Hurricane of 14 September 1944</u>		
Hartford, Conn.	9:50 P.M.	28.94
New Haven, Conn.	8:50 P.M.	28.86
Block Island, R.I.	10:09 P.M.	28.34
Point Judith, R.I.	10:20 P.M.	28.31
Westerly, R.I.	9:40 P.M.	28.43
Milton, Mass. (Blue Hill Observatory)	--	28.62
<u>Hurricane of 31 August 1954</u>		
New London, Conn.	10:00 A.M.	28.26
New Haven, Conn.	9:10 A.M.	28.77
Storrs, Conn.	11:00 A.M.	28.20
Block Island, R.I.	10:00 A.M.	28.5
Milton, Mass. (Blue Hill Observatory)	--	29.9

B-8. DESIGN RUNOFF

The fresh water runoff from the drainage areas behind the barriers was computed using a 10-year 6-hour rainfall based on data in the U.S. Department of Commerce Weather Bureau Technical Paper No. 29, Rainfall Intensity-Frequency Regime, Part 4, Northeastern United States. This gave a total 6-hour rainfall of 3.4 inches which was assumed to coincide with the hurricane tidal surge.

At the Powder Island Barrier the runoff from the 197 acres would have a maximum rate of 315 cfs and a volume of 46 acre-feet. At the Shaw Cove barrier the runoff from the 865 acres would have a maximum rate of 900 cfs and a volume of 210 acre-feet.

HYDRAULICS

B-9. HURRICANE OR STORM-TIDE FLOOD LEVELS

The heights of tidal flooding experienced at a number of locations in the New London area during Hurricane "Carol" (1954) were obtained in the course of damage-survey work in the field for the southern New England coastline. The elevation of these flood levels, referred to mean sea level, were then determined by a field level party. This information was supplemented by material on high water levels collected by this office after the September 1938 hurricane. Based on this information, profiles have been prepared of the 1938 and August 1954 tidal-flood elevations between Willets Point, New York at the western end of Long Island Sound, and Wareham, Massachusetts at the eastern end of Buzzards Bay. A map and profile for the coastline between the Connecticut River on the west and the Connecticut-Rhode Island state line on the east have been prepared. (See Plates B-1 and B-2. At approximately mile 97-00, New London, a general level of 9.7 feet, m.s.l. in 1938 and 8.9 feet, m.s.l. in 1954 are indicated.

Tidal elevation-frequency data is shown in Table B-6 for New London, Connecticut. The New London frequency-curve, Plate B-3, represents a composite curve based on the 146-year period 1815-1960 that influences the upper portion of the curve and the 22.5-year period July 1938-December 1960 for which there is a continuous tide gage record that determines the lower portion of the curve. High water information along the shores of Long Island Sound and Narragansett Bay indicates that the highest tidal-flood levels in the 146-year period occurred during the hurricanes of 1938 and 1954 ("Carol").

TABLE B-6

TIDAL ELEVATIONS VS. FREQUENCY DATAHURRICANES AND SEVERE STORMSNEW LONDON, CONNECTICUT

<u>Hurricane of Storm</u>	<u>Maximum Tidal Elevation (feet, m.s.l.)</u>		<u>Percent Chance of Occur-</u>	
			<u>rence in any one yr. (1)</u>	
			<u>1815-1960)</u>	<u>July 1938-</u>
				<u>Dec. 1960</u>
Hurricane, 21 Sept. 1938	9.7	(2)	0.34	2.2
Hurricane, 31 Aug. 1954	8.9	(2)	1.03	6.7
Storm, 25 Nov. 1950	6.7	(3)		11.1
Hurricane, 14 Sept. 1944	6.2	(4)		15.6
Hurricane, 12 Sept. 1960	6.0	(3)		20.0
Storm, 7 Nov. 1953	5.9	(3)		24.4
Storm, 19 Feb. 1960	5.0	(3)		28.9
Storm, 12 Nov. 1947	4.9	(3)		33.3
Storm, 3 Mar. 1942	4.7	(3)		37.8
Storm, 30 Nov. 1944	4.6	(3)		42.2
Storm, 16 Feb. 1958	4.6	(3)		46.7
Storm, 16 Mar. 1956	4.5	(3)		51.1
Storm, 20 Mar. 1958	4.5	(3)		55.6
Storm, 2 Dec. 1942	4.4	(3)		60.0
Storm, 14 Feb. 1960	4.4	(3)		64.4
Storm, 3 Nov. 1951	4.3	(3)		68.9
Storm, 6 Mar. 1943	4.2	(3)		73.3
Storm, 12 Dec. 1944	4.2	(3)		77.8
Storm, 22 Nov. 1945	4.2	(4)		82.2
Storm, 16 Oct. 1955	4.2	(3)		86.7
Storm, 29 Dec. 1959	4.2	(3)		91.1
Storm, 31 Oct. 1947	4.1	(3)		95.6
Storm, 21 Nov. 1944	4.0	(3)		100.0

(1) Calculated plotting Position:

$$P = \frac{100(M-0.5)}{Y} \text{ where}$$

P= percent chance of occurrence in one year.

M= number of the event.

Y= number of years of record

(2) Based on high water marks at New London, Conn.

(3) Based on U.S.C. & G.S. recording tide gage reading at New London Harbor, New London, Conn.

(4) Estimated by U.S.C. & G.S.

B-10. PONDING

The volume of runoff which would drain into Shaw Cove from the 865 acres would be 210 acre-feet during the 6 hours that the gate would be closed while the tide level is above that in Shaw Cove. The maximum rate of inflow into Shaw Cove would be 900 c.f.s. A pumping station with a capacity of 400 c.f.s. would be designed to discharge fresh water flow through the barrier. Wave overtopping of the barriers would occur during the higher stage of the hurricane tide. Available storage in Shaw Cove, between mean low water and elevation 4.5 feet, mean sea level, would be 84 acre-feet. The pumping capacity combined with the storage available would prevent the pool from rising above significant damage level.

The drainage area behind the Powder Island barrier is 197 acres and the pool area is about 9 acres. The runoff from the design 10-year 6-hour rainfall could be stored during the 6 hour period of hurricane tidal flooding without the pool rising above damage level. If the maximum wave overtopping occurred simultaneously with the design runoff some minor damage would occur due to pool buildup.

B-11. DESIGN STORM-TIDE DERIVATION

A memorandum dated 17 May 1957 to the Beach Erosion Board from the Department of Oceanography of the Agricultural and Mechanical College of Texas, under contract to make surge calculations of Long Island Sound, is the basis for design surge for New London Harbor. The evaluation of design storm surges for Long Island Sound was made by verification of analytical computations with information observed on high water levels in the Sound during the 1938 hurricane. The wind and barometric pressure patterns utilized in the 1938 hurricane problem were taken from U.S. Weather Bureau Memorandum HUR 7-8, dated 1 June 1956. Storm speeds of the design hurricane were for 30 knots and 40 knots, with the latter condition most critical in the eastern and western portions of the Sound, and the 30 knot speed producing higher surges in the central portions. The design hurricane was considered to move on a north-south track so that the region of maximum winds was directed into the southern sound entrance between Block Island and Montauk Point. The design hurricane corresponds to a transposition of the 1944 hurricane, which was especially severe off Cape Hatteras with the wind field and pressures as specified in U.S. Weather Bureau Memoranda Nos. HUR 7-13 and 7-21, dated 1 August 1956 and 23 January 1957, to the Chief of Engineers and is about equivalent to a Standard Project Hurricane at the mouth of Long Island Sound. In New London Harbor, to allow for differences between observed and computed surges in the 1938 hurricane, the computed design surge for the 40 knot storm was modified by the ratio of the observed 1938 surge to the computed 1938 surge. To determine

a design still water level, the design surge was added to a spring tide equivalent to a mean spring high water elevation. The results for New London Harbor are summarized as follows:

Design storm surge (40 knot speed), feet	12.5
Mean spring high water, feet, m.s.l.	1.5
Design still water level, feet, m.s.l.	<u>14.0</u>

The ratio of design surge to the 1938 surge is approximately 1.35.

B-12. DESIGN WAVE HEIGHTS

A design maximum significant wave height of 8.7 feet was derived from deep water wave curves, modifying the results for shoaling. A maximum half-hour wind velocity of 90 miles per hour from the southeast and a 20 statute mile fetch (17.4 nautical miles) from Fort Pond Bay, Long Island, to the entrance of New London Harbor and the South Section of Powder Island barrier was used. Maximum significant wave height for the East Section of Powder Island was reduced to 7.7 feet due to refraction and at the Shaw Cove barrier the wave height was reduced to 4.0 feet due to both refraction and diffraction.

The significant wave height, the average of the highest one-third of the waves in the train, was used as a basis for the determination of the stone size for slope protection, amount of overtopping and barrier top elevation where rock and earth fill structures were involved. However, the maximum wave height, 1.58 times the significant height and one percent frequency of occurrence in the wave train was used for the structural design of walls and gates and to determine the height of runup. Waves exceeding 0.78 of the water depth will break and transform from oscillatory waves to waves of translation; therefore design wave heights were limited by depth of water in certain locations.

The average wind velocities from Fort Pond Bay, Long Island, to the entrance of New London Harbor during the design hurricane were obtained from the isovel charts in the U.S. Weather Bureau's Memorandum HUR 7-72 dated 29 December 1960. The maximum average wind of 90 miles per hour was assumed to occur about one-half hour prior to the design peak still water level as did the maximum winds in the 1938 and 1954 hurricanes. Averages of one-half hour time intervals of wind and water surface elevations were used in determining the average height of significant or maximum waves and periods. The wave periods were determined by the relationship of $H_s/T^2 = 0.22$; where H_s is the significant wave height in feet and T is the period in seconds.

B-13. WAVE RUNUP AND OVERTOPPING

The amount of overtopping is important not only in the design of a safe structure but also from the standpoint of flooding that may be caused by the ponding of the overtopping water. The amount of overtopping was calculated by a method derived by the Beach Erosion Board staff and was determined for one-half hour intervals as noted above, using average significant wave heights, periods, and average still water levels computed for each time interval throughout the design surge period.

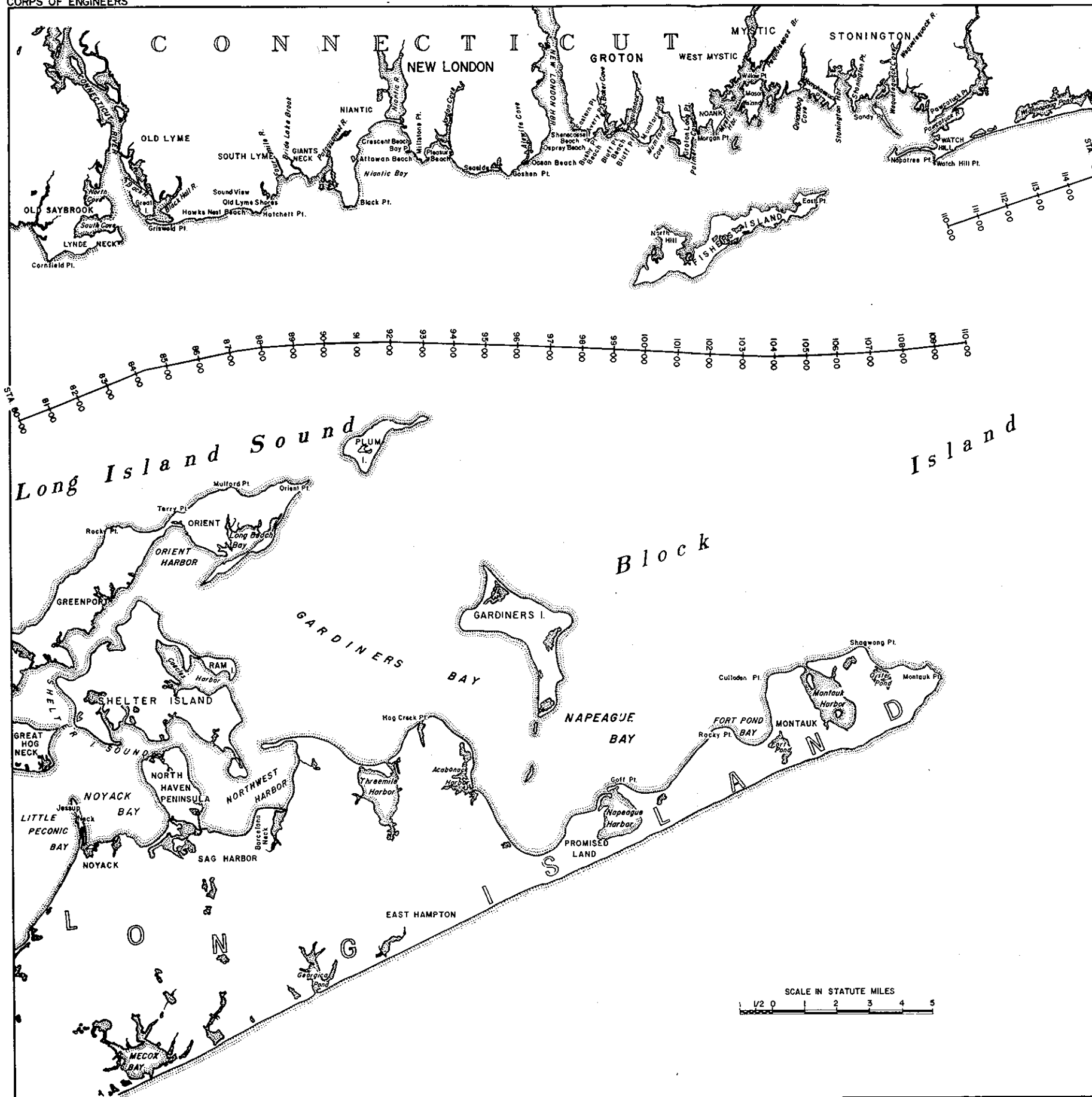
Overtopping values were obtained by interpolation and extrapolation of the curves in the Beach Erosion Technical Memorandum No. 64 entitled, "Laboratory Data on Wave Runup and Overtopping on Shore Structures." Since the wave heights in a wave train vary considerably from wave to wave, it was necessary to determine partial values of overtopping associated with each height in the wave spectrum. These values were then weighted according to the relative frequency of occurrence of the particular height and then summed for the final value of overtopping associated with a wave train of given significant height.

Wave runup data were obtained from Paper 925 of the Journal of the Waterways Division of the American Society of Civil Engineers, Volume 82, No. WW2, April 1956, by Thorndike Saville, Jr., entitled, "Wave Runup on Shore Structures." Runup, the vertical rise of water above the still water level of 14.0 feet, m.s.l. in the design hurricane, ranges between 6 feet and 13 feet at the Powder Island barrier and between 4 feet and 9 feet at the Shaw Cove barrier for 1 on 2 armor stone slopes. On the gate structure of the navigational opening in the Powder Island barrier the calculated runup reaches approximately 6 feet above still water level and at the Shaw Cove gate the runup reaches approximately 9 feet. The amount of overtopping for the navigation gates, is practically negligible due to the short length of structures.

Overtopping at Powder Island barrier, with the proposed top elevation of 22.5 feet, m.s.l., was computed to be 190 c.f.s. resulting in a volume of 8 acre-feet for the maximum one-half hour period. Overtopping during the design tide would extend over a period of 1 to 1½-hours with a total volume of 16 acre-feet. At the Shaw Cove barrier, with the proposed top elevation of 18.0 feet, m.s.l., the overtopping was computed to be 235 c.f.s. resulting in a volume of 10 acre-feet for the maximum one-half hour period and the duration of overtopping would extend for 1-hour with a total volume of 19 acre-feet.

B-14. NAVIGATION VELOCITIES

Currents in the navigation opening through the Shaw Cove barrier and in the small boat opening through the Powder Island barrier were computed for normal tidal conditions. Computations were based on the assumption that the time rate of change of water elevation in the pools behind the barriers would be the same with the barriers in place as before. Multiplying the maximum rate of change in elevation by the pool areas gave the maximum volume rate of flow through the openings. Dividing this discharge by the cross-sectional area of the opening gave the velocity. The maximum average flood and ebb currents in the navigation opening through the Shaw Cove barrier would be about 0.2 knot and in the small boat opening through the Powder Island barrier they would be less than 0.5 knot.



Sound

Island

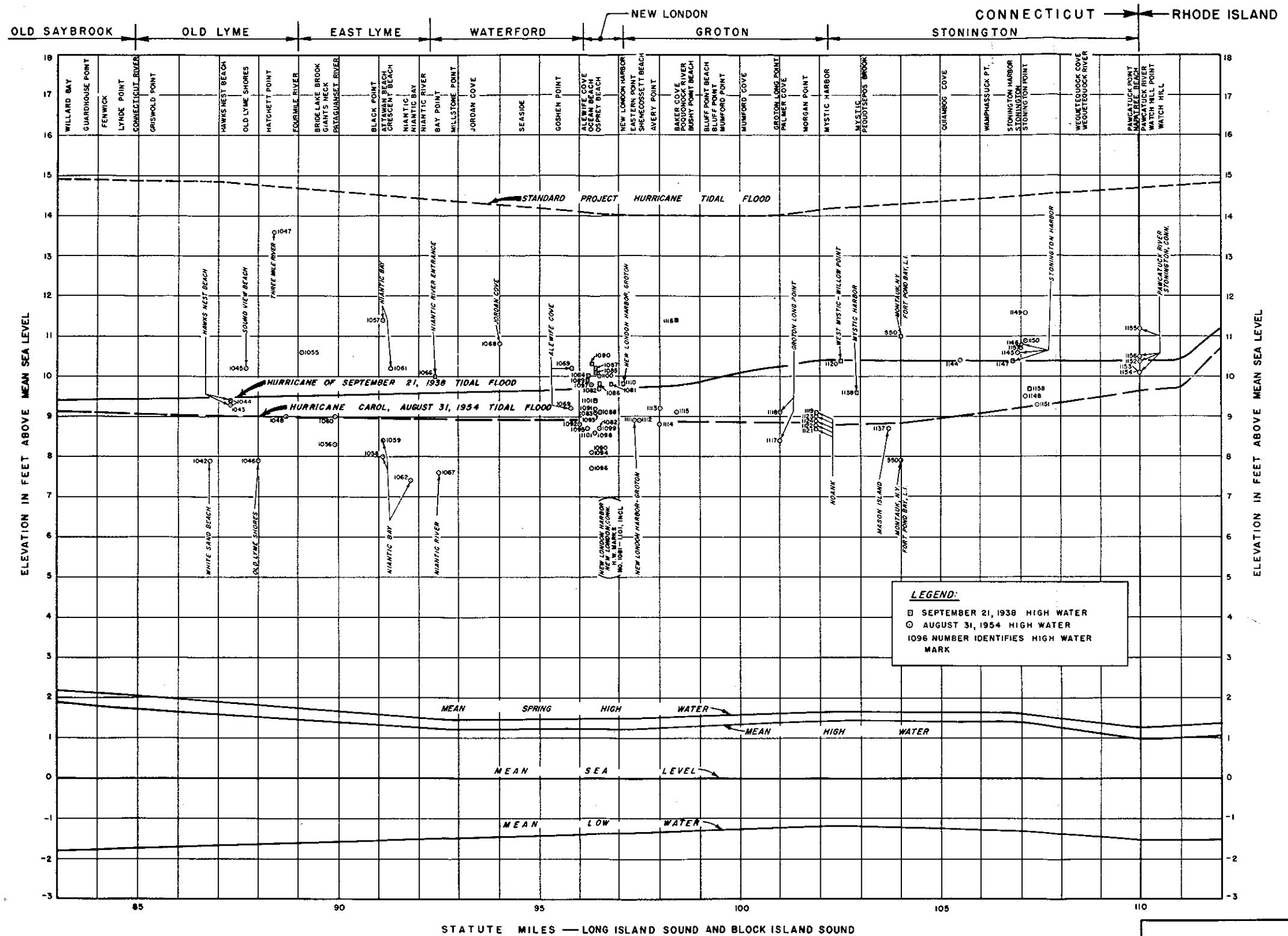
Block

NOTE:

Stationing is in Statute Miles.

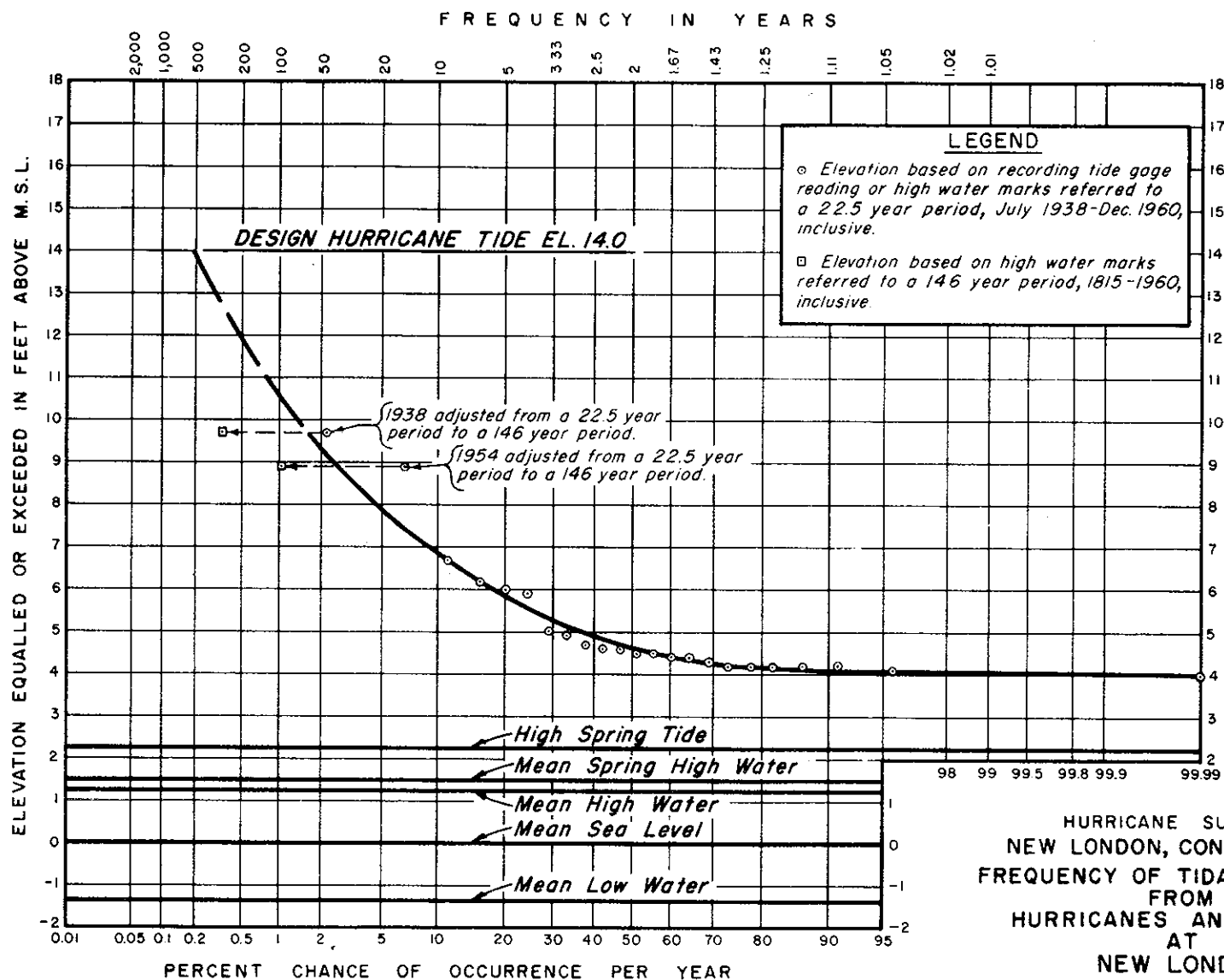
HURRICANE SURVEY
NEW LONDON, CONNECTICUT
LOCATION MAP FOR
HURRICANE FLOOD LEVELS PROFILE
FROM CONNECTICUT RIVER TO
CONNECTICUT-RHODE ISLAND STATE LINE

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB. 1961
SCALE AS SHOWN



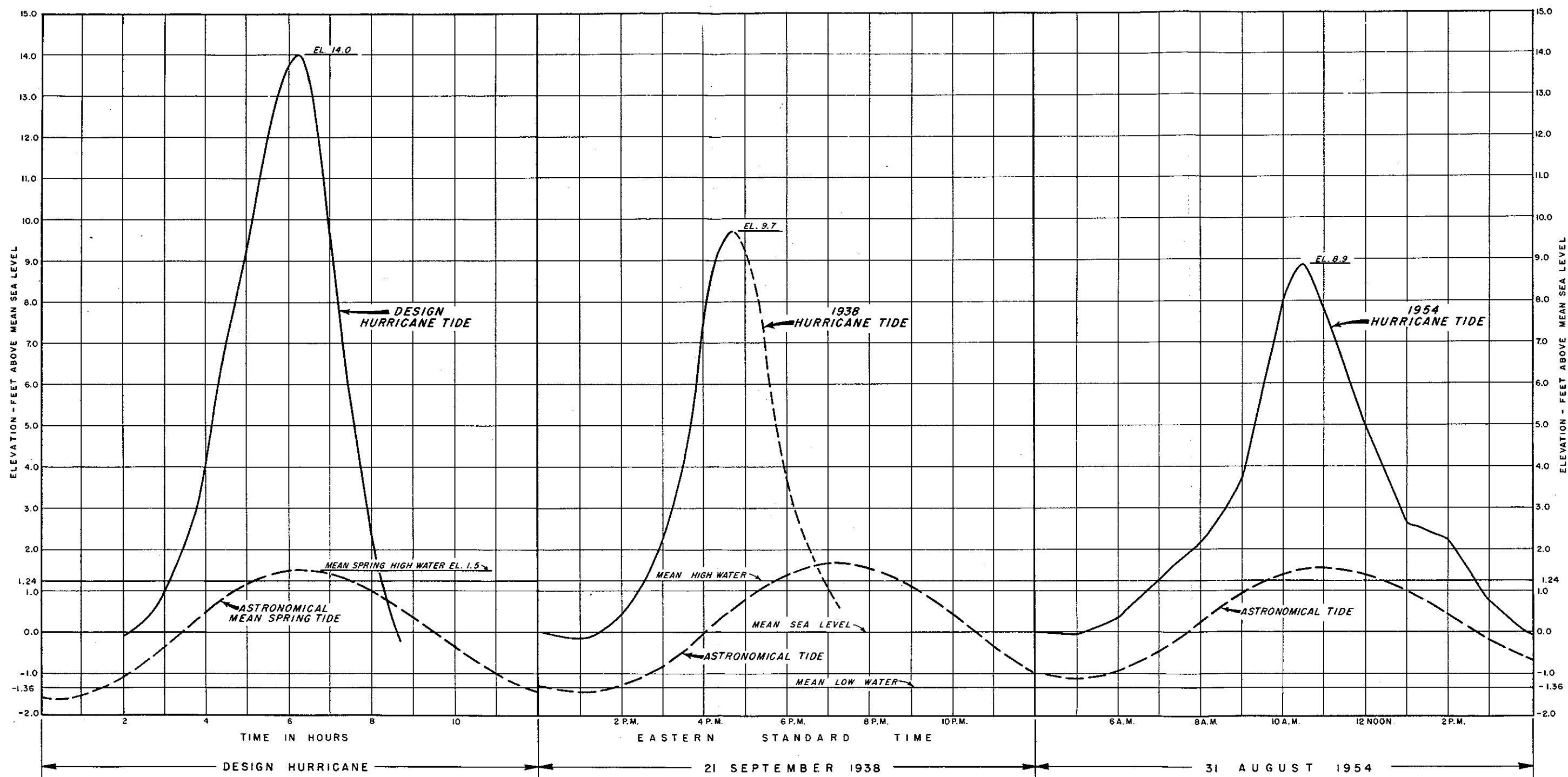
HURRICANE SURVEY
NEW LONDON, CONNECTICUT
HURRICANE FLOOD LEVELS PROFILE
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SCALE AS SHOWN



HURRICANE SURVEY
NEW LONDON, CONNECTICUT
FREQUENCY OF TIDAL FLOODING
FROM
HURRICANES AND STORMS
AT
NEW LONDON

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB. 1961



NOTE:

Design hurricane tide curve based on Texas A&M surge calculations for a design storm with a track most critical to Long Island Sound and with the peak of the surge coincident with the peak of an astronomical mean spring tide.

NOTE:

1938 - Hurricane tide curve based on U.S.C. & G.S. recording tide gage record and estimated tidal heights at New London.

NOTE:

1954 - Hurricane tide curve based on U.S.C. & G.S. recording tide gage record at New London.

HURRICANE SURVEY
NEW LONDON, CONNECTICUT
TIDE CURVES
DESIGN HURRICANE, - 1938 & 1954
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MARCH 1961

APPENDIX C
FLOOD LOSSES AND BENEFITS

APPENDIX C

APPENDIX C
FLOOD LOSSES AND BENEFITS

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APPENDIX C

FLOOD LOSSES AND BENEFITS

GENERAL

C-1. DAMAGE SURVEYS

A preliminary flood damage survey was made in the New London area immediately after the 1954 hurricane. Detailed damage surveys were conducted in 1957. The latter survey consisted largely of door-to-door inspections and interviews of owners and operators of the various commercial, industrial, public and residential buildings affected by tidal flooding. The information obtained included the extent of areas flooded, descriptions of properties including changed conditions since the 1954 hurricane, the nature and amount of damages, depths of flooding, high water references and relationships between the August 1954 flood and other tidal-flood stages. Investigators obtained damage estimates from property owners or tenants when available. Those estimates were reviewed by the investigator and modified consistent with the investigator's judgment, damages to similar properties, and evidence developed from the survey. In other cases, estimates of damage were prepared by the investigator. Sampling methods were often used where properties of the same general type were subject to the same depth of flooding. Data on damages to public property, utilities and highways were obtained from central sources and applied to field information. The survey area included the entire shore line of New London, extending from the city line in the north to Ocean Beach and including the east bank of Alewife Cove.

Sufficient data were obtained to derive losses at (1) the August 1954 flood stage, (2) a stage 3 feet higher, (3) the stage at which damage begins, referenced to the August 1954 flood stage and (4) intermediate stages where marked increases in damage occurred.

C-2. LOSS CLASSIFICATION

Flood loss information was recorded by type of loss and by location. The types of losses recorded included urban (commercial, residential and public), industrial, utility, highway and railroad.

Tangible, primary losses were evaluated. Primary losses comprise (1) physical losses, such as damage to structures, equipment and stock, and the cost of cleanup and repairs, and (2) non-physical losses, such as unrecoverable losses of business, wages, increased cost of production and cost of temporary facilities.

The primary loss resulting from physical damage and as much as the related non-physical loss as possible were determined by direct inspection of flooded properties and evaluation by property owners, field investigators or both. Where necessary, the non-physical losses were estimated by utilizing relationships between physical and non-physical losses determined for similar properties in the survey area and other areas. No evaluations were made of intangible losses including such items as hazards to life, health and personal security.

HURRICANE TIDAL FLOOD DAMAGE

C-3. TIDAL FLOOD LOSSES

Heavy losses were experienced in the New London area during the hurricane of August 1954 when the flood stage reached a level 8.9 feet above mean sea level, approximately 1.0 feet below the record flood stage experienced in 1938. Damages along the shore line of New London, from the city line in the north to Ocean Beach in the south and along the east bank of Alewife Cove, amounted to about \$3,810,000. In the project area (from Customhouse Wharf north of Shaw Cove to a point just north of Greens Harbor) tidal flooding caused damages of nearly \$2,370,000. Damage areas are described in Table C-1 and are shown on Plate C-1.

C-4. TYPE AND DISTRIBUTION OF LOSS

Residential and commercial buildings located on low ground along the shore line of New London were seriously flooded. The 210 commercial establishments and 280 residences suffered losses of over \$3,120,000 which represents about 80 percent of the total tidal-flood damage in New London. A tabulation of 1954 experienced tidal-flood losses in New London is presented in Table C-1 by damage areas and by types of losses.

In Area I, the area north of Shaw Cove (from the northerly city limit to the Customhouse Wharf) losses caused by tidal flooding during the hurricane of August 1954 amounted to about \$260,000. Nearly all of the 58 commercial establishments and 90 residential properties in the flood prone area are located in the mile and a half reach extending from the Customhouse Wharf to the State Pier. First floor flooding up to depths of 2 feet were experienced by some 20 commercial firms, 48 dwellings, 2 public buildings and the industrial firm of Deredon Food Company. Additional heavy losses were averted in the State Pier yards by relocation and elevation of stock above the flood level and beyond the flooded area. The New York-New Haven and Hartford Railroad station and yards were flooded. In 1938 the main railroad line was blocked by stranded vessels including one 180-foot lighthouse tender.

TABLE C-1

EXPERIENCED TIDAL FLOOD LOSSESHURRICANE CAROL, 31 AUGUST 1954NEW LONDON, CONNECTICUTLosses in Thousands of Dollars

<u>Area</u>	<u>Description</u>	<u>Urban</u>	<u>Industrial</u>	<u>Highway</u>	<u>Railroad</u>	<u>Utility</u>	<u>Total</u>
I	Northerly city line to Customhouse Wharf (upstream of Shaw Cove)	150	100	-	10	-	260.0
II	Customhouse Wharf to Greens Harbor	1800	490	10	-	70	2,370.0
III	Greens Harbor to east bank of Alewife Cove	1170	-	-	-	10	<u>1,180.0</u>
							3,810.0

In Area II, extending from the Customhouse Wharf to a point just north of Greens Harbor, approximately 143 commercial establishments, 119 residential properties and 6 industrial plants sustained losses totaling about \$2,370,000. Damages to commercial and residential buildings accounted for over three-fourths of this amount. In the Shaw Cove area several boat yards suffered extensive damages to piers, wharves, storage sheds, and numerous small craft moored in the cove. Flooding up to depths of 3 feet over first floors were noted in the highly commercialized district of Bank Street from Blinman Square to the New England Historical Society and in the industrialized area just north of Greens Harbor.

In Area III, Greens Harbor to Alewife Cove, losses amounted to about \$1,180,000. Nearly the entire amount was experienced by some 68 dwellings and 8 commercial establishments. In the low areas around Ocean Beach several amusement enterprises experienced flood stages up to 4 feet above the grounds, accompanied by heavy wave action. During the 1938 hurricane, approximately 200 summer cottages were swept away from the same area. Five boat yards and a yacht club suffered serious losses. Craft torn from their moorings crashed into piers, wharves, and into structures, causing partial or total destruction. During the 1938 hurricane damages of \$400,000 occurred from Alewife Cove to Quinipeag rocks. This area is to be studied in detail and included in a Long Island Sound report.

Damages were also experienced on the railroad right-of-way and by utility substations and underground service lines in the flood area. Losses to automobiles marooned in the flood area are only partially included in the damage totals due to sparcity of available data. Damages to floating craft are discussed in paragraph C-10.

C-5. RECURRING LOSSES

Stage-loss curves referenced to the 1954 tidal-flood level have been developed as a basis for economic analysis. Prepared from the data collected in the recent damage surveys, these stage-loss curves afford a means of determining the magnitude of recurring losses at any stage of flooding up to 3 feet above that experienced in 1954. A breakdown of the losses to be anticipated in New London and in the project area in the event of future hurricanes is shown at 1961 price levels in Table C-2.

ANNUAL LOSSES AND BENEFITS

C-6. GENERAL

The total benefit to the plan providing protection against hurricane flooding in the Shaw Cove-Powder Island area of New London comprises benefits from flood damage prevention, the elimination of emergency costs, the increased utilization of lands, and prevention of damage to floating craft.

TABLE C-2

RECURRING TIDAL FLOOD LOSSES IN NEW LONDON
(1961 Price Level)

<u>Recurring Hurricanes</u>	<u>Flood Stage</u> (ft., m.s.l.)	<u>Entire City</u> <u>of New London</u>	<u>New London Local</u> <u>Protection Area</u>
21 September 1938	9.7	\$5,500,000	\$3,200,000
31 August 1954	8.9	4,280,000	2,470,000
14 September 1944	6.2	250,000	70,000
12 September 1960	6.0	160,000	30,000
<u>Other Storms</u>			
25 November 1950	6.7	560,000	230,000
7 November 1953	5.9	120,000	20,000

C-7. AVERAGE ANNUAL TIDAL-FLOOD LOSSES

Recurring flood losses in the project area have been converted to average annual losses by correlating stage-damage and stage-frequency relationships to derive a damage-frequency curve. The area under this curve, which has been plotted with damage as the ordinate and with percent chance-of-occurrence (the reciprocal of frequency) as the abscissa, is a measure of the average annual loss. The stage-damage, stage-frequency, and damage-frequency curves are plotted on Plate C-2. The average annual loss in the area protected by the protection plan amounts to \$220,000.

C-8. AVERAGE ANNUAL DAMAGE-PREVENTION BENEFITS

Average annual benefits from the prevention of tidal-flood losses have been derived by determining the difference between the average annual losses under present conditions and the average annual losses remaining after construction of the project. A stage-frequency curve affecting post project conditions was utilized in developing residual damages. The average annual flood-damage prevention benefits attributable to the plan total about \$218,000.

C-9. EMERGENCY COST BENEFITS

In addition to actual tidal-flood damage, significant costs are incurred in the areas subject to flooding due to instituting temporary protective measures upon receipt of hurricane warnings whether flooding occurs or not. Based on data gathered in the course of damage surveys in New London and in other areas subject to tidal flooding, it is estimated that 25 percent of the commercial establishments in

the flood area attempt to minimize their potential losses through temporary prevention measures. A more detailed study was made to determine costs associated with hurricane warnings at the seven industrial concerns. It is estimated that emergency costs in the project area would amount to \$38,500 for each hurricane warning. Based on a frequency of four hurricane warnings in a 10-year period, the average benefit from the elimination of emergency costs amounts to \$15,400.

C-10. ENHANCEMENT BENEFITS

a. General. An analysis of flood losses and benefits in New London revealed that substantial development of lands currently idle is expected to follow the construction of the hurricane protection project. The value of the enhancement of land would be an additional benefit to the project. There is a demand for land suitable for development at locations in the established industrial and commercial zones of the community. Recent commercial and industrial developments have been located in the outskirts or suburbs due to scarcity of space in the downtown area and the flood history of the waterfront segment of the city. An Urban Renewal Program is being initiated in an adjoining flood free downtown area which will provide 25 acres of commercial and industrial lands. An experience of three major hurricane floods in a 25-year period, together with minor storms and several hurricane threats, precludes the development of idle lands in the project area.

An extensive investigation of past, present, and potential future use of idle lands and vacant industrial and commercial space was made to obtain data for the economic analysis. In the course of this investigation, valuable data was obtained from responsible sources including city officials, bankers, real estate brokers, industrial managers, and representatives of the Chamber of Commerce and state and local development commissions. The results of this study revealed a demand for idle lands in or adjacent to the existing commercial and industrial area.

New London is typical of several communities in the northeastern section of the country in that it developed the core of its business and service facilities along the river and water front. The bottom of the valley was used for business and industry and the hillsides for residences. The valley portion of New London has long been densely developed and demands on the service facilities such as banking, retail outlets, wholesale distributors, and rail and boat transportation have increased with the population surge of the surrounding towns. The high level of employment in boat yards, U. S. Navy and Coast Guard establishments, electronic and machine tool industries and increased pleasure boat and tourist activity have created a demand for additional commercial facilities. In several instances in recent years operators of supermarkets, trucking terminals, wholesale food distributors, and light industries have investigated the development of idle lands and redevelopment

of currently occupied lands in the flood area. In each instance, awareness of the flood history has terminated all interest. At the same time, similar developments have taken place outside the flood area.

b. Development of Idle Land. There are four pieces of land within the project area which have a high potential of development with the removal of the flood threat. The present value, development cost and future value are set forth in Table C-3. The area of these four segments amounts to 18.3 acres. The largest segment comprising 8.0 acres is presently tidal flats without utility. Construction of the hurricane protection project will permit filling of the land, construction of an access road from the existing water front street and provide a site for supermarket, boatel, marina facilities, truck terminal or other commercial facilities. A second area comprising 1.7 acres is located at the intersection of two streets and is presently used by a junk dealer. Elimination of the flood hazard will permit utilization of this corner lot for stores or other commercial use. The remaining two parcels containing 5.7 and 2.9 acres are presently idle lots without adequate street frontage. Removal of seven (7) existing structures will permit development of these lands for commercial enterprise.

Enhancement benefits have been estimated on a basis of a future value of \$17,400 per acre. This value approximately \$0.40 per square foot is consistent with the land values in the business district of New London outside the flood area. The state and local development commissions indicate it to be a reasonable estimate of future value. Development costs have been based on estimates of cost of existing structures, demolition and removal costs and cost of filling, grading, and access road where applicable. The removal of existing structures will reduce annual losses, and flood damage prevention benefits by less than one percent. The increase in capital value of land has been estimated at \$108,000. A return of 6 percent annually after taxes is common for investment purposes in this type of property in the New London area. This return on the enhancement of \$108,000 will yield \$6,500 annually. The demand for land in the area is such that the idle land will undoubtedly be developed within 4 years after construction of the project. Based on a uniform realization of enhancement benefits between completion of the project and 4 years thereafter, an annual equivalent benefit of \$5,900 has been derived.

C-11. PREVENTION OF DAMAGE TO FLOATING CRAFT

It is estimated that Shaw Cove would accommodate about 180 boats and Benthleys Creek about 32 boats. The boats in Benthleys Creek marina are subject to flood and wave damage, while those in Shaw Cove are better

TABLE C-3

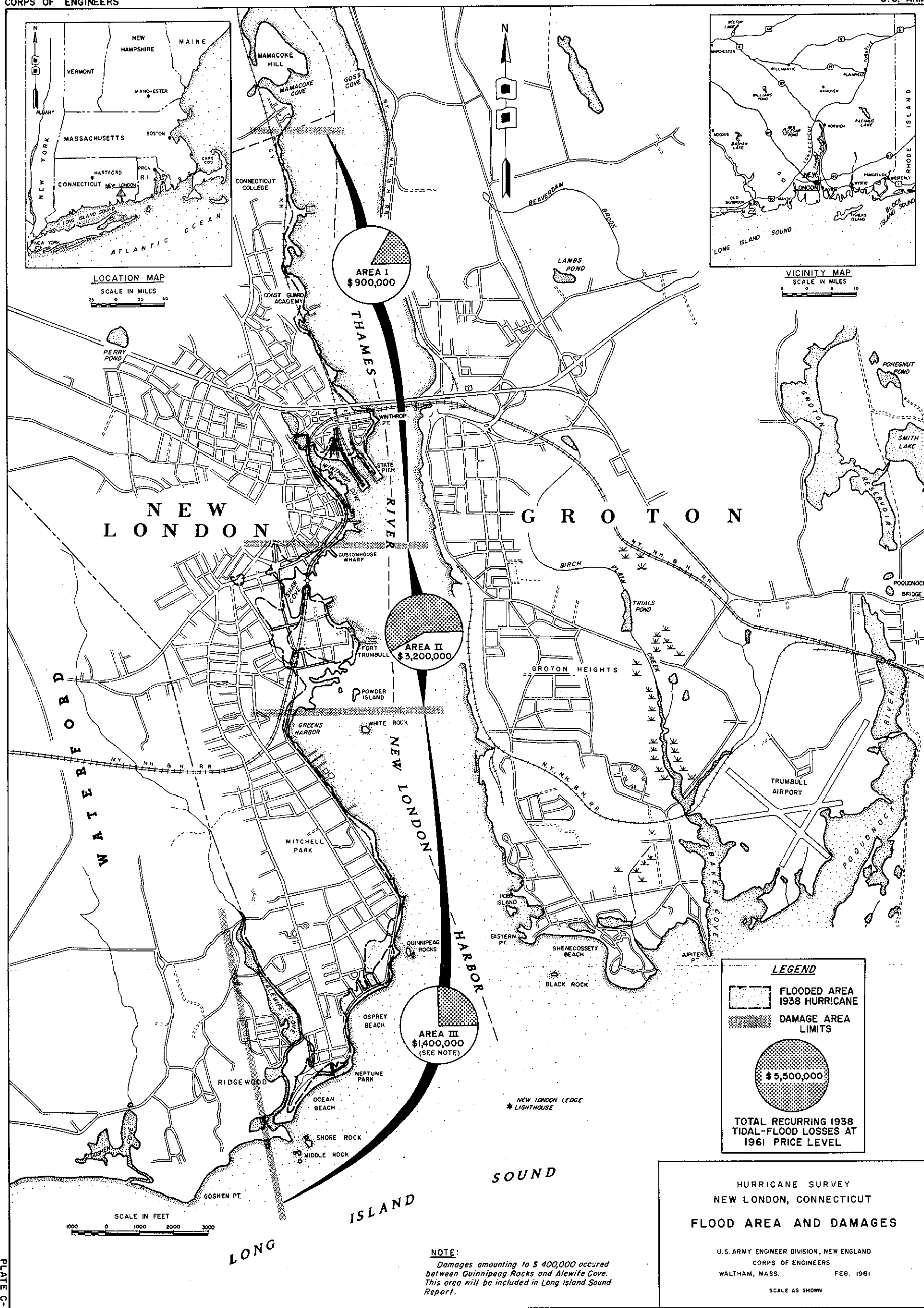
ENHANCEMENT OF IDLE LANDSNEW LONDON, CONNECTICUT

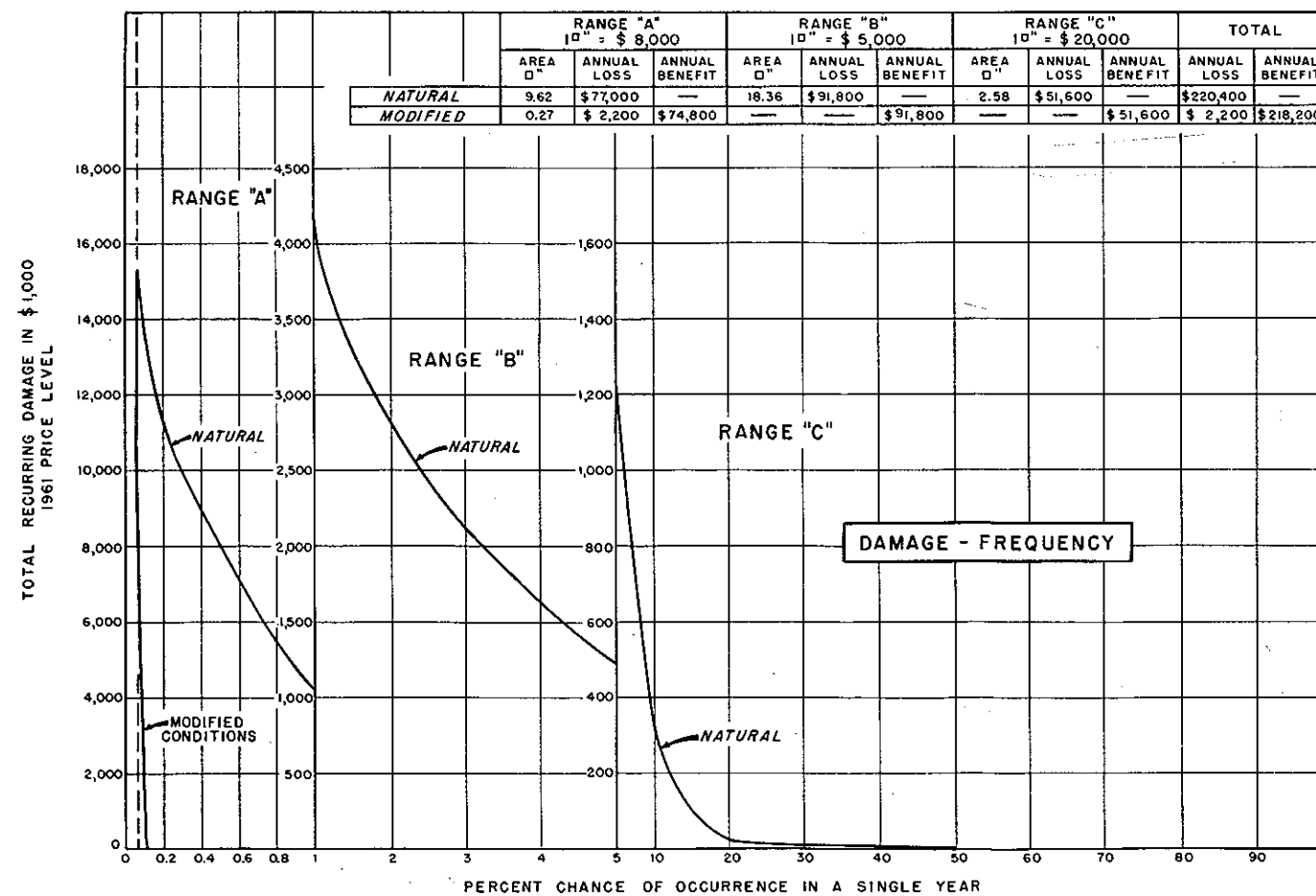
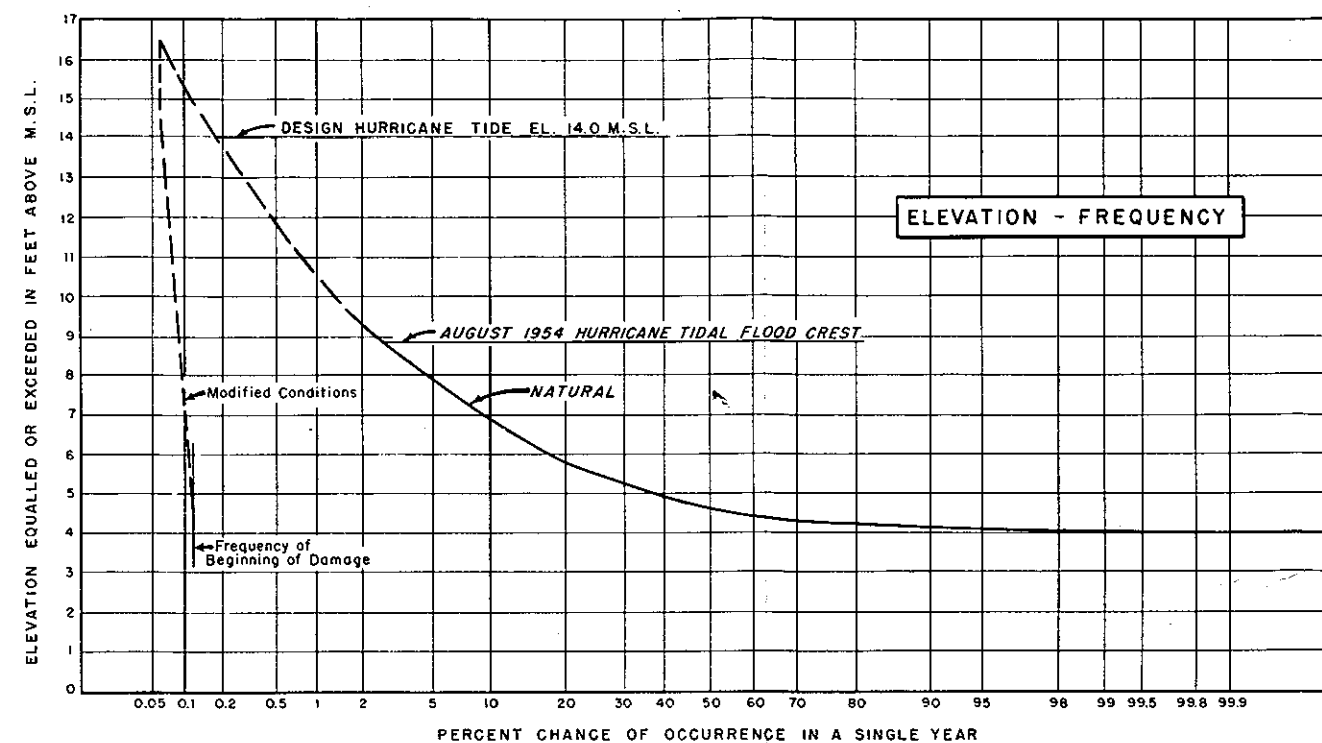
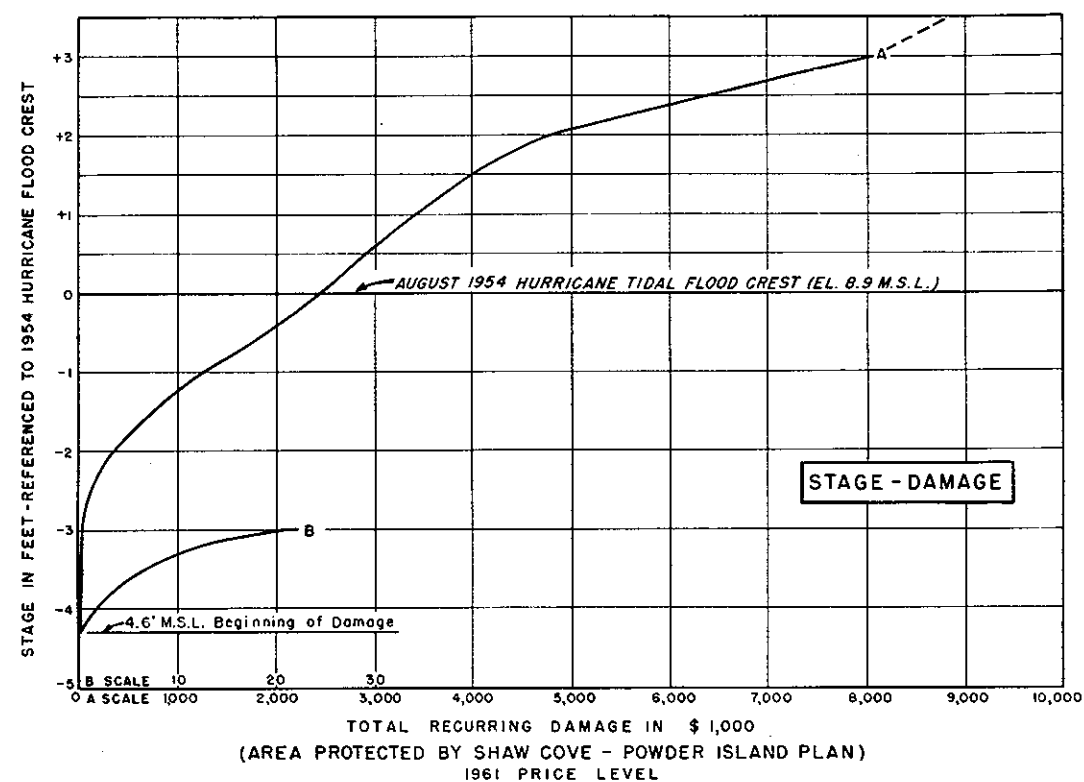
<u>Location</u>	<u>Area</u>	<u>Type of Development Anticipated</u>	<u>Present Value</u>	<u>Development Cost</u>	<u>Future Value</u>	<u>Increase in Value</u>
Pequot Ave. - rear of New London Mills	8.0 Acres	Commercial or Light Industry	\$ 6,800	\$ 77,200	\$138,900	\$ 54,900
Pequot Ave. - Trumbull St. Nameaug St.	1.7 Acres	Commercial	10,000	-	29,700	19,700
Howard St. Hamilton St. Powerhouse Lane	5.7 Acres	Commercial or Light Industry	40,400	36,000	99,200	22,800
Howard St. Harris St. Hamilton St.	2.9 Acres	Commercial	12,900	26,700	50,200	10,600
Total	18.3 Acres		\$70,100	\$139,900	\$318,000	\$108,000

protected. Wave action is moderate except when flood levels and waves overtop the railroad embankment. It is estimated that annual damage of \$50 per boat would be prevented with the construction of the barriers, making an annual benefit of \$11,000.

C-12. SUMMARY OF BENEFITS

Total annual benefits of \$250,300 attributable to the protection provided by the New London protection plan include \$218,000 flood-damage prevention benefits, \$15,400 elimination of emergency costs, \$5,900 increased utilization of lands, and \$11,000 of boat damage prevented.





HURRICANE SURVEY
NEW LONDON, CONNECTICUT
CURVES FOR ECONOMIC ANALYSIS

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MARCH 1961

APPENDIX D
DESIGN STUDIES AND COST ESTIMATES

APPENDIX D

APPENDIX D

DESIGN STUDIES AND COST ESTIMATES

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APPENDIX D

DESIGN STUDIES AND COST ESTIMATES

INTRODUCTION

D-1. The design features and cost estimates for the recommended plan of hurricane protection for New London, Connecticut, consisting of the Shaw Cove and Powder Island barriers and related land walls, are presented in this appendix. The principal features of the plan are shown on Plate D-1.

Design and cost estimates for the selected plan are based on recent field surveys and subsurface investigation. Terrain and land features were evaluated from Army Map Service Sheet 6566 1 SE, scale 1:25000, U.S. Coast and Geodetic Survey Chart No. 359; aerial photographs by the Department of Agriculture; and Army Engineers Topographic and Hydrographic surveys completed in 1959.

D-2. GEOLOGY

New London, Connecticut, lies on the western flank of a narrow topographic funnel stem draining the Thames River Basin, an elliptically shaped area of 1,474 square miles most of which lies in Connecticut on the southern edge of the New England upland between the Connecticut River basin and the Narragansett Bay basin.

The structural origin of the steep-walled Thames River estuary has been variously ascribed to fjord-like glacial erosion of a pre-glacial stream valley or simply to drowning of the river valley. The hills bordering the estuary attain elevations of about 300 feet, with frequent bedrock exposures, mostly Lower Paleozoic granitic gneiss which occurs throughout much of the area and extends into western Rhode Island. Overburden on the hills is mostly sandy till, with intervening small marshy areas containing some outwash sand and gravel. Fringes of low-lying outwash deposits with marine deposits and artificial fills occur along the project alignment on the New London waterfront.

Coverage for this survey report stage of investigations consisted of geological reconnaissance supplemented by 7 test borings. Overburden samples were obtained by continuous drive sampling and bedrock was diamond-drill cored in 3 of the borings. Additional information was available in the form of foundation borings made by others for the railroad bridge across the mouth of Shaw Cove (See Plate D-3).

DESIGN CRITERIA

D-3. The structures have been designed for protection against a Standard Project Hurricane flood. Studies were also made for alternative plans with lower top elevation, however, it was found that the reduction in average annual flood damages prevented was substantially less than savings in annual charges, based on the reduced construction cost of the lower structures. Extension of the protection beyond the limits shown on the plan was considered, but thinly scattered damages would not justify the cost of protective structures. Design criteria and the selected top elevations are shown in Table D-1 below. Appendix B contains details of design tidal flood and design waves.

The design of structures has followed published standards of the Chief of Engineers and Beach Erosion Board. The rock protection for the barriers is based on general criteria developed by the Waterways Experiment Station.

TABLE D-1

DESIGN CRITERIA AND SELECTED TOP ELEVATION

NEW LONDON, CONNECTICUT

Design Hurricane still water elevation (feet above m.s.l.)	14.0
Maximum significant wave height (feet)	
Powder Island Barrier	8.7
Shaw Cove Barrier	4.0
Top elevation of barriers (feet above m.s.l.)	
Powder Island Barrier	22.5
Shaw Cove Barrier	18.0
Top elevation of land walls (feet above m.s.l.)	15.0 to 22.5

SELECTED PLAN OF PROTECTION (Shaw Cove-Powder Island Plan)

D-4. DESCRIPTION OF PLAN

a. General. The selected plan of protection (See Plate D-1) consists of a barrier and concrete wall system extending from the Ferry Dock on Pequot Avenue to high ground at Fort Trumbull; a concrete wall crossing lowlands west of Fort Trumbull; and a barrier and concrete wall system crossing the entrance of Shaw Cove and extending from high ground south of the Cove northward to the vicinity of the Customhouse Wharf. The barriers and structures included in the plan of improvements are described below.

b. Powder Island Barrier. The barrier would be of earth-fill, rock-faced construction with a top elevation of 22.5 feet above m.s.l., and a top width of 10 feet, with a paved approach and turnaround at the north abutment of the small boat opening. (See Plate D-1 for details).

(1) Small boat opening. The Benthleys Creek channel would be crossed by a 30.0-foot wide by 27.5-foot high gated concrete structure. Gate design and operation would be similar to Shaw Cove gate described in paragraph d (1), below. Navigation depth would be 7 feet below m.l.w.

(2) Land walls. The Powder Island barrier would be tied to high ground by means of mass concrete gravity walls located at both ends of the alignment. Highway openings through the walls would be closed by means of a 40-foot wide by 12-foot high swing gate at Pequot Avenue, and a 20-foot wide by 11-foot high stoplog structure at Fort Trumbull.

c. Smith Street Land Wall. A mass concrete gravity land wall with a top elevation of 15.0 feet, m.s.l., would prevent back flooding through low land west of Fort Trumbull.

d. Shaw Cove Barrier. The barrier would be of earth-fill, rock-faced construction with a top elevation of 18.0 feet above m.s.l., and a top width of 10 feet, with paved approaches and turnarounds at the abutments. The embankment design would provide for the replacement of organic silt with sand fill in that portion of the alignment south of the navigation opening. (See Plate D-1 for details.)

(1) Navigation opening. The gated navigation opening at Shaw Cove would have a sill elevation of 18.0 feet below m.s.l., and a clear width of 46 feet. The navigation depth would be 17.0 feet below mean low water. The gate would be of fabricated steel of the lift-up type, and would be open hinged at a bottom sill. Design would provide for floating the gate from the sill for maintenance and repair. The gate would be operated by a tainter gate type hoisting system housed on the abutments. The machinery would be synchronized for control from either house. For details of the gate see Plate D-2.

(2) Pumping station. Fresh water behind the Shaw Cove barrier would be evacuated by means of a 400 c.f.s. pumping station during the time when the gate was closed.

(3) Land wall. The northern end of the alignment would be closed by means of a mass concrete gravity land wall and a 25-foot wide by 11-foot high stoplog structure across the railroad.

e. Pertinent data. Information relating to the New London Plan is summarized in Table D-2.

TABLE D-2

PERTINENT DATAHURRICANE PROTECTION - NEW LONDON, CONNECTICUT

(SHAW COVE AND POWDER ISLAND BARRIERS)

Powder Island Barrier

Type:	Earth-fill, rock faced
Top elevation	22.5 feet, m.s.l.
Length (including small boat opening)	3,260 feet
Maximum height (above river bottom)	33.0 feet
Top width	10 feet
Side slopes	
Above mean sea level	1 on 2
Below mean sea level	1 on 3

Small boat opening

Type:	(gated)
Width	30.0 feet
Sill elevation	- 8.0 feet, m.s.l.
Height of structure	27.5 feet (above sill)
Navigation depth	7.0 feet, m.l.w.

Shaw Cove Barrier

Type:	Earth-fill, rock faced
Top elevation	18.0 feet, m.s.l.
Length (including gated navigation opening)	1,760 feet
Maximum height (above river bottom)	36.0 feet
Top width	10 feet
Side slopes	
Above mean sea level	1 on 2
Below mean sea level	1 on 3

Navigation Opening

Type:	Lift-up, bottom hinged
Width of navigation opening	46 feet, clear
Top elevation	16.5 feet, m.s.l.
Sill elevation	18.0 feet, m.s.l.
Height of gate	34.5 feet (above sill)
Navigation depth	17.0 feet, m.l.w.

TABLE D-2 (continued)

PERTINENT DATAHURRICANE PROTECTION - NEW LONDON, CONNECTICUT(SHAW COVE AND POWDER ISLAND BARRIERS)Pumping Station

Structure: Reinforced concrete

Pumps

4 - 48 inch

Design capacity

400 c.f.s. @ 16 ft. head

Stoplog Structures

Type: Railroad

1

Street (Fort Trumbull)

1

Width of opening

Railroad

25.0 feet

Street (Fort Trumbull)

20.0 feet

Height of opening

11.0 feet

Pequot Avenue Gate

Type: Swing Gate

Width of opening

40.0 feet

Height of opening

12.0 feet

Land Walls

Type: Concrete gravity

Top elevation

Powder Island Barrier

22.5 feet, m.s.l.

Shaw Cove Barrier

18.0 feet, m.s.l.

Smith Street

15.0 feet, m.s.l.

Maximum height (above ground)

15.0 feet

D-5. FOUNDATION CONDITIONS

a. Powder Island Barrier. Two borings were made along the southern arm of the Powder Island barrier, indicating 5 to 14 feet of granular materials overlying fairly compact inorganic silts interbedded with sands. The surface sands were variably loose, ranging in blows per foot of sample spoon penetration from 2 to 24. The landward boring (FD-7) encountered refusal at 35.1 feet below mean sea level while no refusal was met in (FD-6), the outer boring, which was stopped while in compact silty sands at 46.1 feet below mean sea level. Several bedrock outcrops on shore and on small islands along the alignment do not necessarily indicate that the stoplog structure can be founded directly on firm materials.

b. Shaw Cove Barrier.

(1) South abutment. The south abutment is the lower north flank of a granitic gneiss knob covered, in that area, by probably not more than 5 feet of sodded firm overburden which near the waters edge is partly fill containing some junk. Bedrock is exposed on the alignment near the shore and again at the end of the alignment, hence no land explorations were required for this stage of investigation.

(2) North abutment. (Concrete Wall and Stoplogs). The area, partly paved, was not explored. Underlying materials are assumed to be granular backfills with some trash, probably of the better sort such as brick, meeting firm original ground at shallow depth except nearer the water front where a layer of organic silt probably separates fill and underlying granular materials.

(3) Water crossing. Water depths average approximately 5 feet, mean sea level, south of the proposed navigation gate and about 18 feet north of the opening. Borings indicate that the surface of bedrock under the planned gate structure is 52 to 54 feet below mean sea level, the deeper figure to the south. The rock, granitic gneiss, appears sound and hard, with high bearing capacity, and a gently undulating surface, curving upward to about elevation minus 30 feet near the shore and downward again along the shore line to slightly below elevation minus 50 feet at the north end of the water section.

A contrast in overburden types exists north and south of the navigation opening, with relatively compact granular materials ranging from 6 to 30 blows per foot of sample spoon penetration underlying 1 to 5 feet of soft organic silt north of the opening, the greater depth of soft silt occurring along the shore at the extreme north. South of the opening soft organic silts attain depths in excess of 20 feet, extending to about 28 feet below mean sea level. A 5 to 15-foot thickness of silty sand underlies most of this deposit south of the channel, but approaching the southern edge of the opening the organic silt is underlain by fairly compact (about 15 to 30 blows per foot) inorganic silts attaining about a 25-foot thickness at the south channel margin. The inorganic

silt layer thins out to the north to a thickness of about 10 feet lying between an upper 12-foot layer of sand and a 13-foot layer of gravelly sand with boulders, just north of the north channel margin. Approaching land, to the north, the overburden is only about 12 feet thick, with gravel overlying gravelly sand. Farther north, materials are finer grained, but still granular except for a thin deposit of sandy inorganic silt at considerable depth (See Plate D-3, Log of FD-1), and a few feet of overlying organic silt. The materials retained behind the bulkhead along the northern part of the alignment are unknown, but they are presumed predominantly granular and compact, possibly with considerable rubble, since a railroad mainline operates close to the edge of the bulkhead. It is possible that depths of organic silt greater than 5 feet will be encountered beneath portions of the toe of the north portion of the barrier.

D-6. SELECTION OF EMBANKMENT SECTIONS

a. Foundation preparation. The sections of the embankment selected for the barriers are shown on Plate D-1. The site investigations described in the above paragraphs indicate that, in general, the foundation for the embankment consists of firm granular soils and bed-rock except in the area south of the gated navigation opening of the Shaw Cove Barrier. To obtain a firm foundation for the entire reaches of the embankment, the soft natural material south of the navigation opening would be excavated and replaced with suitable fill material. Between stations 10 and 18 of the Powder Island Barrier, it would be necessary to remove industrial waste which has been placed north of the existing rock dike. With these preparations, the foundation would be adequate to support a barrier with conventional side slopes.

b. Characteristics of fill and seepage control. The embankment sections have been selected considering availability and characteristics of fill materials, construction features, foundation conditions, seepage control requirements and the effect of wave action. The stone protection on the river side was based on Waterways Experiment Station criteria as noted in paragraph D-3. The stone protection, gravel sections and in some locations, a rock toe on the land side of the embankments has been provided to control seepage through the embankments and their foundations. The fill portions of the embankments would be composed of two types of fill. Below an elevation of approximately 2.0 feet above mean sea level, the fill would consist of well-graded sand or gravelly sand having an in-place angle of internal friction of at least 30 degrees. This material would be placed by dumping and the side slopes would probably be between 1 on 3 and 1 on 4, depending upon weather conditions and construction operations. The placement of fill in this manner would permit construction by land methods. Fill material above the dumped fill would be either silty sand or sandy glacial till, either of which are available within a reasonable land haul distance, placed in layers and compacted by rolling.

c. Embankment sections. The embankment sections selected are considered adequate for the purpose of this study. The main difference in the embankment sections in river areas and those on land is the placement of dumped fill below approximately elevation 2.0 feet above mean sea level. Special care would be required in the selection of the dumped fill material to provide a zone with a high shearing strength. With this precaution, the embankments should have an ample factor of safety against a failure by shear, considering the purpose of the structure.

d. Concrete structures. The concrete land walls and stoplog structures are located where the foundations consist mainly of firm natural ground or granular type fill. These materials would serve as an adequate foundation for the structures. Some type of foundation cut-off may be necessary for the stoplog structure. The foundation conditions for the Pequot Avenue gate structure and the small boat opening structure, Powder Island Barrier, have not been investigated. For the purpose of this study, it has been assumed that foundation piling will be required for these structures. The foundation overburden soils for the Shaw Cove navigation structure are indicated on the geologic section shown on Plate D-3. The upper soft organic silt at the site would be removed and replaced with suitable fill material to the extent shown on Plate D-1 to provide stability of the wrap-around embankment slopes. The foundation conditions dictate a piling foundation for the structure. A sheet pile foundation cut-off would control seepage beneath the structure. The pumping station would be founded on bedrock.

D-7. AVAILABILITY OF CONSTRUCTION MATERIALS

Rock. Several minor quarries have operated in and near New London. They are mostly inoperable owing to residential and urban development. Other quarrying possibilities exist within ten miles haul distance, since the dominant rock type in the area is granitic gneiss and outcrops of sufficient high relief occur in the area. It appears doubtful that local quarrying would compete with commercial sources, however, since operating high quality monumental granite quarries exist at Millstone Point in Waterford, Niantic, and at Westerly, Rhode Island; approximately 6 miles, 10 miles, and 15 miles haul distances, respectively. Trap rock quarries in the New Haven area also may furnish competitive prices at the site.

Earthen borrow. Pervious sands and gravelly sands can be obtained in sufficient quantities for barrier fills approximately 5 miles haul distance from the site. A possible source of glacial till lies approximately 3 miles haul distance from the site. Rapid suburban development may interfere with some of these sources, but all materials can be obtained well within a ten mile radius, in a northwesterly direction.

Concrete aggregates. There are two commercial sand and gravel concerns producing concrete aggregates in New London and two additional

sources within 15 miles haul distance of the site. Relatively small requirements for the job indicate transit-mix. Two commercial transit-mix plants are located within 15 miles of the site.

D-8. MODIFICATION TO SEWERAGE AND DRAINAGE FACILITIES

The sewage treatment outfall would be extended to discharge outside of the Powder Island barrier. Existing storm and industrial drains located on the protective alignment would be extended to discharge outside the barriers and would be provided with check valves to prevent back flooding during hurricanes. Sewer outfalls discharging into Shaw Cove would be unaffected by the protection plan.

D-9. LANDS AND DAMAGES

The cost of furnishing necessary lands, easements and rights-of-way, a requirement of local cooperation, has been estimated upon the basis of a field reconnaissance and the application of current market values as determined from a study of a number of recent sales in the area. The estimate includes allowances for the payment of severance damages and acquisition costs. The lands and improvements to be acquired and the land upon which temporary or permanent easements will be secured are summarized below.

Land:

Acquired in fee, for structures	2.2 acres
Construction easements, temporary	1.7 acres
Permanent easements	0.9 acres
Improvements	
Buildings	7 each
Dock	1 each

D-10. RELOCATIONS

The construction of the plan does not require relocation of highways, railroads, or utilities.

D-11. PLAN OF CONSTRUCTION

The construction of the New London plan would require approximately two years. The construction schedule, predicated on the construction in the dry by cofferdamming of the navigation gate structure, the pump station and the small boat opening structure, would be generally as follows:

a. During the first year site preparation and access roads would be completed, organic material south of the navigation gate would be replaced by sand fill, cofferdams for the pumping station,

Shaw Cove navigation gate structure, and Powder Island small boat opening structure would be constructed, and pile foundations for water structures would be driven. Rock excavation for the pumping station would be accomplished upon completion of the cofferdam.

b. Construction of the navigation gate structure, pumping station, small boat opening structure, barriers, and walls, would be completed in the second year of construction. Sewer modifications would be made concurrently with construction of the barriers.

BASIS OF ESTIMATES OF FIRST COST AND ANNUAL COSTS

D-12. COST ESTIMATES

The cost of the plan has been estimated on the basis of a design which would provide economical and safe structures. Embankment quantities are based on the typical cross sections and details shown on Plate D-1 and include allowance for settlement.

D-13. UNIT PRICES

Unit prices are based on averages for similar types of projects either constructed, under construction, or under contract in New England and where applicable, similar construction in other parts of the country. Adjustments have been made for the availability and sources of material required. The adopted unit prices, which are on a 1961 price level basis, also reflect adjustments to include minor items of work.

D-14. CONTINGENCIES, ENGINEERING AND OVERHEAD

The estimate includes a 20 percent allowance to cover contingencies. The cost of engineering and design, supervision and administration are estimated lump sums based on knowledge of the site and recent experience. These items of cost for various phases of the plan are as shown in Table D-3.

D-15. LOCAL CONTRIBUTIONS

Local interests would be required to contribute 30 percent of the first cost of the project (less costs for preauthorization survey studies and navigation aids), comprising (1) a cash contribution to the United States, presently estimated at \$819,000; (2) lands, easements and relocations necessary for the construction of the project, presently estimated at \$180,000; and (3) sewer and drainage modifications necessary for the construction of the project, presently estimated at \$30,000.

D-16. ANNUAL COSTS

The estimate for annual costs is based on 2-5/8 percent interest on the Federal investment cost and 3.5 percent interest on the local

investment cost and amortization of the investment over a period of 50 years. The total investment, Federal plus non-Federal, equals the first cost plus $2\frac{5}{8}$ percent interest on the Federal first cost and 3.5 percent interest on non-Federal first cost for one year or one-half of the estimated construction period of two years. No allowance has been made for the loss of taxes on lands and improvements necessary for the construction of the project, as it is considered that this loss would be compensated for by taxes on developments which would take place in the area due to the elimination of the flood hazard. Costs of maintenance and operation of the project are based on a knowledge of the site and costs of similar projects.

FIRST COSTS AND ANNUAL COSTS

D-17. FIRST COSTS

The first cost of the plan is estimated at \$3,430,000, of which \$2,401,000 would be borne by the United States. Local interests would contribute in cash \$819,000 and provide all lands, easements and rights-of-way necessary for the construction of the project at an estimated cost of \$180,000 and complete all sewer and drainage modifications necessary for the construction of the project at an estimated cost of \$30,000. The costs of the individual structures are shown in detail in Table D-3. Detailed breakdowns of the estimates, by principal features of the work, and by quantities and unit prices, are also shown in Table D-3.

D-18. ANNUAL COSTS

The total annual costs for the Plan amount to an estimated \$163,000. Of this amount \$92,000 represents Federal annual costs and \$71,000 non-Federal. The determination of annual costs is shown in Table D-4.

TABLE D-3

ESTIMATED FIRST COSTS
(1961 Price Level)
HURRICANE PROTECTION PLAN (SHAW COVE-POWDER ISLAND BARRIERS)
NEW LONDON, CONNECTICUT

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>POWDER ISLAND BARRIER</u>				
Site Preparation	1	Job	L.S.	\$ 3,000
Rock Fill - Armor Stone	45,000	c.y.	6.00	270,000
Rock Fill - Bedding Stone & Quarry Run	32,000	c.y.	4.00	128,000
Rock Fill - Riprap	5,000	c.y.	5.00	25,000
Gravel	15,200	c.y.	2.50	38,000
Earth Fill	154,000	c.y.	1.00	154,000
Paving	1,000	s.y.	2.00	2,000
Small Boat Opening Structure				
Cofferdam and Unwatering	1	Job	L.S.	22,000
Concrete, Reinforced	815	c.y.	65.00	53,000
Concrete Mass	29	c.y.	35.00	1,000
Steel "H" Piles	3,200	L.F.	9.00	29,000
Steel Sheet Pile Cutoff	250	S.F.	4.00	1,000
Gate and Equipment	1	Job	L.S.	62,000
Apron	1	Job	L.S.	1,000
Fender Piles & Dolphins	1	Job	L.S.	6,000
Land Wall (West of Pequot Avenue)	1	Job	L.S.	31,000
Land Wall (Ft. Trumbull)	1	Job	L.S.	14,000
Gate Structure (Pequot Avenue)	1	Job	L.S.	77,000
Stoplog Structure (Ft. Trumbull)	1	Job	L.S.	14,000
				\$ 931,000
Contingencies				186,000
Total Cost - Powder Island Barrier				\$1,117,000

SMITH STREET LAND WALL

Concrete Gravity Wall	1	Job	L.S.	6,000
Contingencies				1,000
Total Cost - Smith Street Land Wall				\$ 7,000

Cost 1860
 1.0
 265.0
 132.0

1,117.0
 7.0
 12243
 2,167

Say 2170

TABLE D-3 (continued)

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>SHAW COVE BARRIER</u>				
Site Preparation	1	Job	L.S.	\$ 7,000
Rock Fill - Armor Stone	16,500	c.y.	6.00	99,000
Rock Fill - Bedding Stone & Quarry Run	7,500	c.y.	4.00	30,000
Rock Fill - Riprap	2,000	c.y.	5.00	10,000
Gravel	7,600	c.y.	2.50	19,000
Earth Fill	108,000	c.y.	1.00	108,000
Dredging	33,300	c.y.	1.50	50,000
Paving	4,000	s.y.	2.00	8,000
Navigation Gate Structure				
Cofferdam and Unwatering	1	Job	L.S.	130,000
Earth Excavation	3,330	c.y.	1.50	5,000
Concrete, Reinforced	677	c.y.	65.00	44,000
Concrete, Mass	885	c.y.	35.00	31,000
Concrete, Tremie	1,320	c.y.	25.00	33,000
Steel "H" Piles	8,444	L.F.	9.00	76,000
Steel Sheet Pile Cutoff	1,250	S.F.	4.00	5,000
Gate and Equipment	1	Job	L.S.	163,000
Fender Piles and Dolphins	1	Job	L.S.	12,000
Apron	1	Job	L.S.	3,000
Pumping Station				
Cofferdam and Unwatering	1	Job	L.S.	40,000
Excavation, Common	4,800	c.y.	2.50	12,000
Excavation, Rock	2,000	c.y.	6.00	12,000
Earth Fill	2,000	c.y.	1.00	2,000
Paving, Yard	1,500	s.y.	2.00	3,000
Apron and Riprap	400	c.y.	5.00	2,000
Concrete, Reinforced	630	c.y.	65.00	41,000
Concrete, Mass	257	c.y.	35.00	9,000
Structural Steel	10,000	Lbs.	0.30	3,000
Pumps and Motors	1	Job	L.S.	187,000
Gates, Flap	4	Ea.	5000.00	20,000
Gates, Slide	1	Ea.	10000.00	10,000
Miscellaneous Equipment	1	Job	L.S.	100,000
Discharge Culvert (Box)	1	Job	L.S.	12,000
Land Wall	1	Job	L.S.	21,000
Stoplog Structure, Railroad	1	Job	L.S.	15,000
				\$1,322,000
Contingencies				265,000
Total Cost - Shaw Cove Barrier				\$1,587,000
ENGINEERING AND DESIGN				271,000
SUPERVISION AND ADMINISTRATION				238,000
TOTAL COST, HURRICANE PROTECTION PLAN				\$3,220,000

TABLE D-3 (continued)

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>LANDS AND DAMAGES</u>				
Land (in fee)	2.2	Acres	L.S.	\$ 41,000
Permanent Easements	0.9	Acres	L.S.	17,000
Temporary Easements	1.7	Acres	L.S.	9,000
Improvements Taken	1	Job	L.S.	50,000
Severance Damage	1	Job	L.S.	34,000
				\$ 151,000
Contingencies				29,000
TOTAL COSTS - LANDS AND DAMAGES				\$ 180,000
SEWER AND DRAINAGE MODIFICATIONS	1	Job	L.S.	25,000
Contingencies				5,000
TOTAL COSTS - SEWER AND DRAINAGE MODIFICATIONS				\$ 30,000
SUMMARY				
HURRICANE PROTECTION PLAN				\$3,220,000
Lands and Damages				180,000
Sewer and Drainage Modifications				30,000
SUBTOTAL - FIRST COST				\$3,430,000
Navigation Aids (To be installed by U.S. Coast Guard)				12,000
Preauthorization Survey Studies				30,000
Estimated First Cost to U.S.				\$2,401,000
Estimated First Cost to Local Interests				\$1,029,000(1)

- (1) Thirty percent of first cost of project includes estimated costs of \$180,000 for lands and damages, \$30,000 for sewer and drainage modifications, and a local cash contribution presently estimated at \$819,000 to the United States.

TABLE D-4

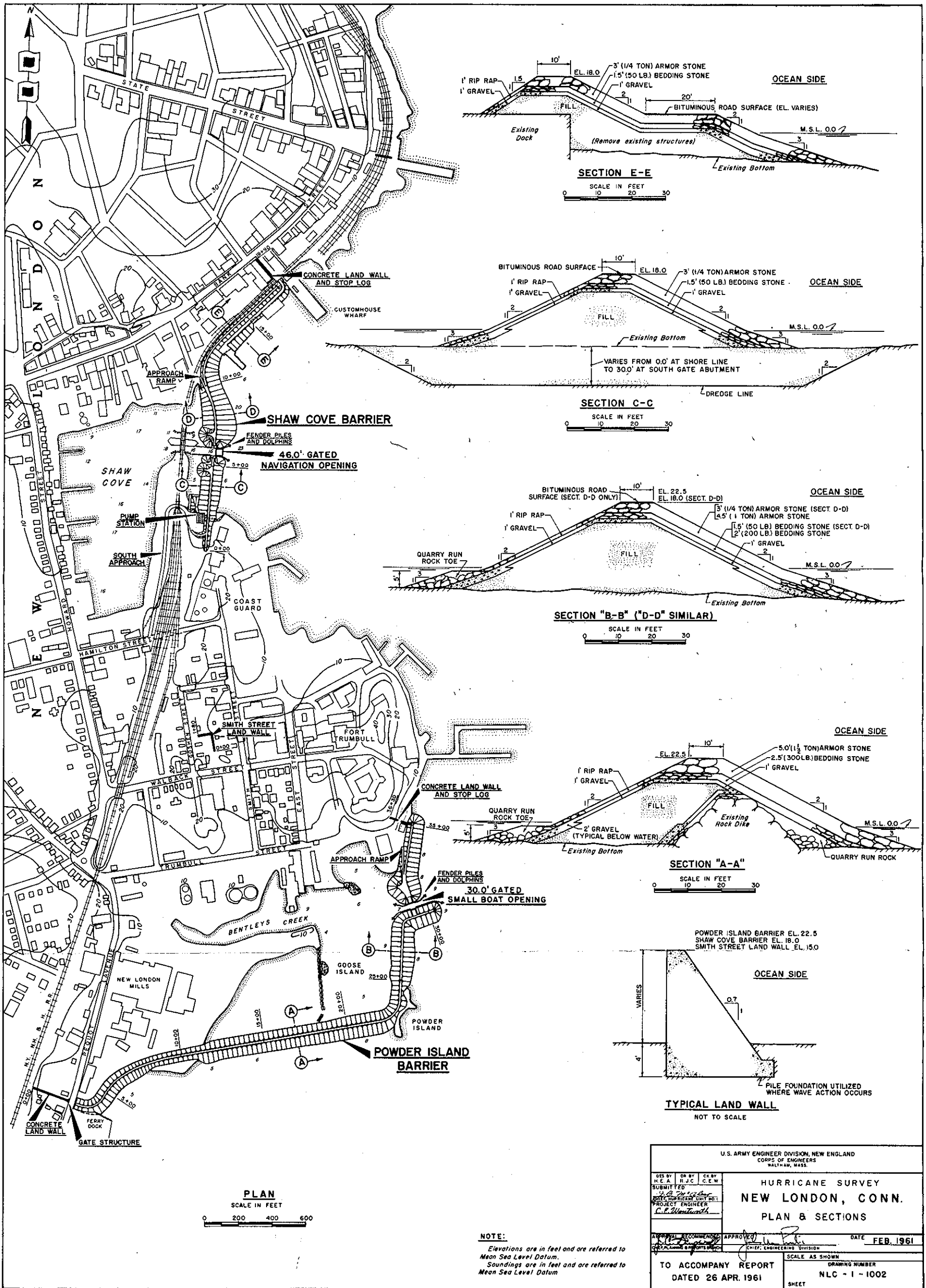
ESTIMATED ANNUAL COSTS
(1961 Price Level)
HURRICANE PROTECTION PLAN - SHAW COVE-POWDER ISLAND BARRIERS
NEW LONDON, CONNECTICUT

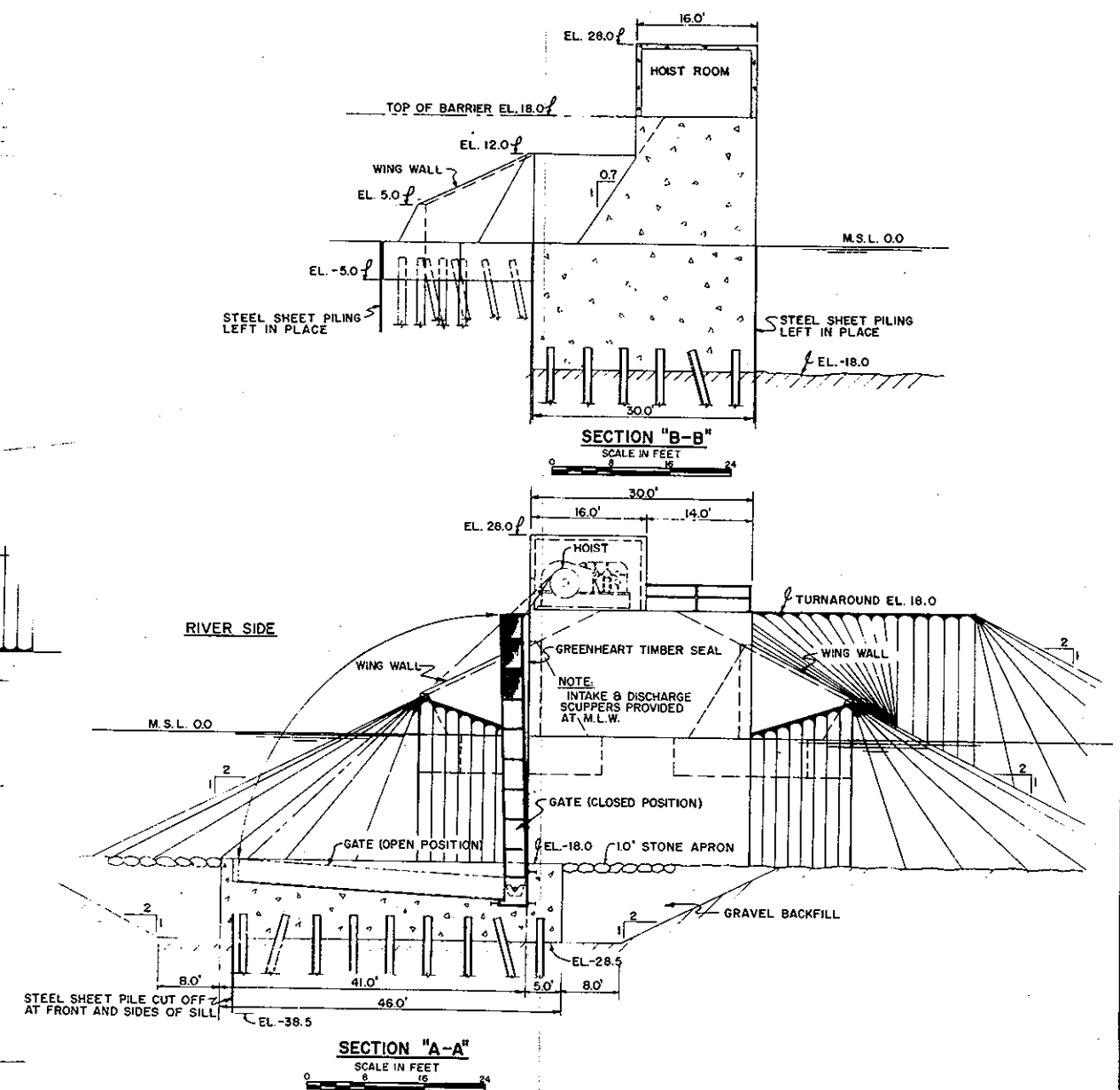
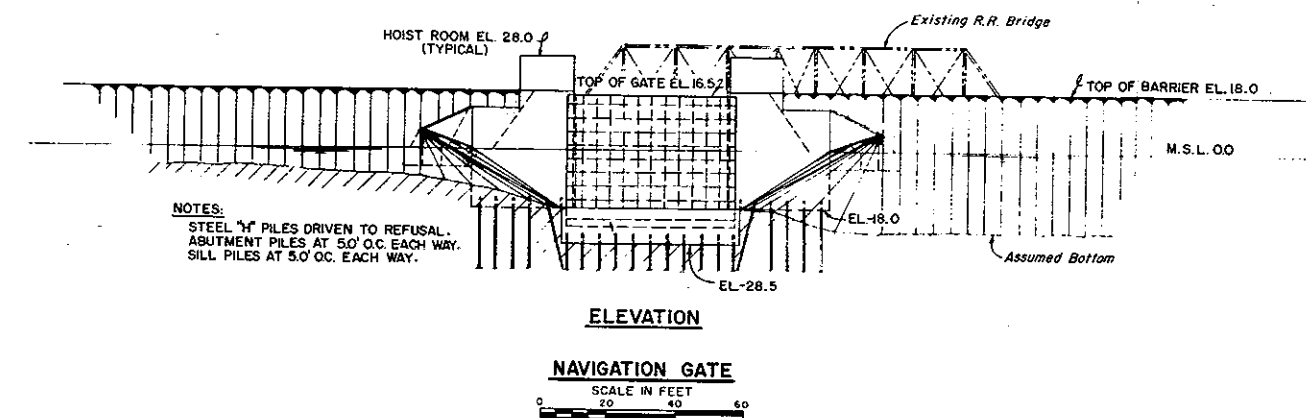
		<u>Annual Costs</u>
<u>Federal Investment Costs</u>		
Total Federal First Cost (From Table D-3)		\$2,443,000 (1)
Interest during construction		<u>64,000</u>
Total Federal Investment Cost		\$2,507,000
<u>Federal Annual Costs</u>		
Interest on Investment, 2-5/8%		\$ 66,000 (2)
Amortization, 0.990%		25,000 (3)
Maintenance and Operation		
Navigation Aids		<u>1,000 (4)</u>
Total Federal Annual Costs		\$ 92,000 (5)
<u>Non-Federal Investment Cost</u>		
Contributed Funds	\$819,000	
Lands and Damages	180,000	
Sewer and Drainage Modifications	<u>30,000</u>	
Total Non-Federal First Cost	\$1,029,000	\$1,029,000
Interest during construction		<u>36,000</u>
Total Non-Federal Investment Cost		\$1,065,000
<u>Non-Federal Annual Costs</u>		
Interest on Investment, 3.5%		\$ 37,000
Amortization, 0.763%		8,000
Maintenance and Operation		
Salaries	\$ 2,000	
Supplies	1,200	
Embankment and General	7,200	
Concrete Features	500	
Navigation Gate and Accessories	1,800	
Pumping Station	2,500	
Stoplog Structures	<u>1,700</u>	
Total Non-Federal Maintenance and Operation	16,900	\$ 16,900

TABLE D-4 (continued)

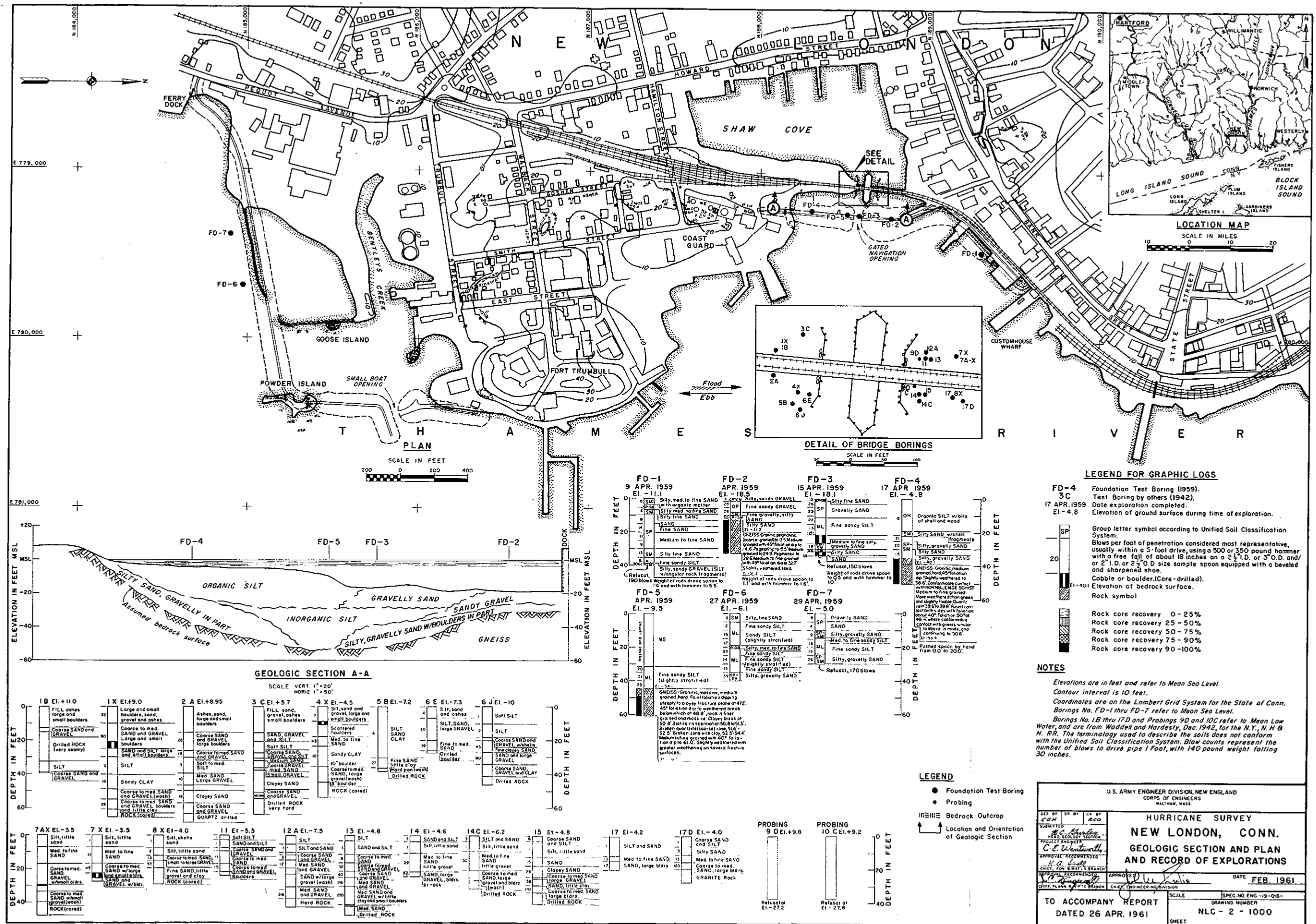
<u>Non-Federal Annual Costs (continued)</u>		<u>Annual Costs</u>
Allowance for Major Replacements		
Pumps and Motors	\$3,000	
Flap Gates, Slide Gates & Miscellaneous		
Pumping Station Equipment	2,100	
Navigation Gate	1,900	
Auxiliary Equipment for Navigation Gate	800	
Gate & Equipment for Small Boat Opening	1,000	
Swing Gate at Pequot Avenue	300	
Total Allowance for Major Replacements	\$9,100	26,0 9,100
Total Non-Federal Annual Costs		71,000
TOTAL ANNUAL COSTS		\$163,000

- (1) Includes \$30,000 for preauthorization survey studies and \$12,000 for navigation aids to be installed by U.S. Coast Guard.
- (2) Includes \$300 annual interest cost to U.S. Coast Guard.
- (3) Includes \$100 annual amortization cost to U.S. Coast Guard.
- (4) Maintenance and operation by U.S. Coast Guard.
- (5) Includes \$1,400 annual costs to U.S. Coast Guard.





DES BY H.E.A.			DR BY W.J.C.			CK BY C.E.W.		
SUBMITTED <i>22 Apr 1961</i> PROJECT HURRICANE UNIT NO. 1 PROJECT ENGINEER <i>C.E. Wankers</i>								
APPROVED <i>[Signature]</i> CHIEF, PLANNING STAFF								
APPROVED <i>[Signature]</i> CHIEF, ENGINEERING DIVISION								
DATE						FEB. 1961		
TO ACCOMPANY REPORT DATED 26 APR. 1961								
SCALE: AS SHOWN DRAWING NUMBER NLC - 1 - 1003 SHEET								



APPENDIX E
LETTERS OF COMMENT AND CONCURRENCE

APPENDIX E

APPENDIX E
LETTERS OF COMMENT AND CONCURRENCE

TABLE OF CONTENTS

<u>Exhibit No.</u>	<u>Agency</u>	<u>Letter dated</u>
E-1	Connecticut Water Resources Commission	Mar. 16, 1961
E-2	City Manager, New London, Connecticut	Apr. 14, 1960
E-3	City Manager, New London, Connecticut	June 30, 1960
E-4	Connecticut Department of Health	Jan. 5, 1961
E-5	Connecticut Board of Fisheries & Game	June 22, 1960
E-6	U.S. Fish and Wildlife Service	Aug. 16, 1960
E-7	U.S. Department of Health, Education & Welfare	July 25, 1960
E-8	U.S. Coast Guard	Jan. 10, 1961



STATE OF CONNECTICUT

WATER RESOURCES COMMISSION

STATE OFFICE BUILDING • HARTFORD 15, CONNECTICUT

March 16, 1961

Brig. Gen. Seymour A. Potter, Division Engineer
Corps of Engineers, U. S. Army
New England Division
424 Trapelo Road
Waltham, Massachusetts

Re: Hurricane Protection Project
New London, Connecticut

Dear General Potter:

This is in further reference to your request concerning the views of this Commission regarding the proposed Hurricane Protection Project for the City of New London.

On the basis of preliminary plans submitted this project has the general approval of this Commission. Undoubtedly details will be discussed as more complete plans are developed for the project.

In the past the assurances which are required have been provided by the State under an agreement between the State and the local municipality. It is intended to follow this procedure in connection with the New London project.

Legislation is now being considered by the present session of our General Assembly authorizing this Commission to participate in tidal and hurricane flooding projects recommended for construction in this State. This Legislation, if approved, would authorize the State to participate in the costs required by the Federal Government from local interests for the construction of such projects. This will facilitate the carrying out of projects of this type in Connecticut if enacted.

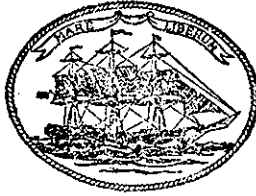
Sincerely,

A handwritten signature in cursive script, reading "William S. Wise".

William S. Wise
Director

WSW:tv

EXHIBIT E-1



CITY OF NEW LONDON
CONNECTICUT

DEPARTMENT OF ADMINISTRATION
EDWARD R. HENKLE
CITY MANAGER

April 4, 1960

United States Army Engineers Division, New England
Corps of Engineers
#424 Trapelo Road
Waltham, Massachusetts (54)

In Re: NEDGW

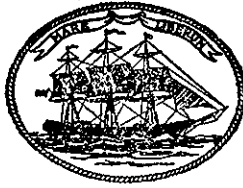
Dear Sirs:

In my opinion the City of New London will contribute its share of the local contribution toward the completion of the above named project. This opinion is bolstered by vote of the Council of the City of New London taken at a regular meeting held Monday, March 21st, 1960 authorizing me to make the above statement.

Very truly yours,

Edward R. Henkle
City Manager

ERH:EMH



CITY OF NEW LONDON
CONNECTICUT

DEPARTMENT OF ADMINISTRATION
EDWARD R. HENKLE
CITY MANAGER

June 30, 1960

United States Army Engineers Division, New England
Corps of Engineers
#424 Trapelo Road
Waltham 54, Massachusetts.

In Re: NEDGW

Dear Sirs:

In my opinion the City of New London will contribute its share of the local contribution towards the completion of the above-named project. This opinion has not changed as a result of the public hearing conducted by the United States Army Engineers Division, New England, Corps of Engineers.

All members of the City Council were present at said hearing and are very much in favor of the proposed project.

Very truly yours,

Edward R. Henkle
City Manager

ERH:EMH

EXHIBIT E-3



STATE OF CONNECTICUT
STATE DEPARTMENT OF HEALTH
STATE OFFICE BUILDING HARTFORD 15, CONNECTICUT



January 5, 1961

STATE OF PUBLIC HEALTH

Colonel Karl F. Eklund
Corps of Engineers
Division Engineer
424 Trapelo Road
Waltham 54, Massachusetts

Dear Colonel Eklund:

In answer to your letter concerning hurricane protection against tidal flooding in New London, the principal point we would like to raise is with regard to the outlet pipe from the main sewage treatment plant of the city of New London. On the small scale map you have sent, it is difficult to plot just where this outlet is with reference to the proposed barriers but we would not be in favor of building the barriers without extension of the pipe out to a point where there would be good dilution.

I have discussed this question with Mr. William S. Wise, director of the state water resources commission, and he agrees with this point. We hope this will be given full consideration and will be glad at any time to discuss it further.

Sincerely yours,

Warren J. Scott

Director
Sanitary Engineering Division

WJS/b

cc: Mr. MacLeman
Mr. Wise

NOTE: Plan provides for extension of discharge pipe from sewage treatment plant. See paragraph 65. of Report.

EXHIBIT E-4



STATE OF CONNECTICUT

BOARD OF FISHERIES AND GAME

2 WETHERSFIELD AVENUE • HARTFORD, CONNECTICUT

ADDRESS ALL MAIL TO
STATE OFFICE BUILDING, HARTFORD

June 22, 1960

The Division Engineer
U.S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Mass.

Re: File No. NEDGW

Dear Sir:

This is in reply to your notice of May 25 concerning a public hearing to be held June 27, 1960 on hurricane tidal flood protection for New London, Connecticut.

The attached map indicates that a barrier is recommended in the vicinity of Shaw Cove and another larger barrier to the south and west of Fort Trumbull. From the cursory description and examination of the plans described in this notice, it appears the project will have no significant adverse effect upon the fish and wildlife resources of the area. This statement is contingent upon a field inspection of the area and on more specific information to be heard at the June 27 meeting. At first glance there seems to be excellent possibilities for multiple use for flood protection and recreation.

The Thames River is potentially one of the best areas along our coast for the development of recreation in the form of sport fishing. It is a very rich estuary and we know that striped bass spend a full 12 months in these waters. Other species that appear in great numbers in season are blue fish, mackerel, smelt and winter flounder. In view of this high recreational potential, we feel there is justification in requesting that the Corps give serious consideration to making slight modification to the proposed hurricane tidal flood protection works. Specifically, such modification should include (1) the acquisition of a parcel of land adjacent to the barrier for parking and access facilities, (2) fishermen should be permitted access to the barrier itself for the purpose of fishing and (3) it would be desirable to have flat stones placed on top of the structure so as to permit a cap that would enhance its use and prevent possible serious injury.

Another consideration is that the above-described access facilities would afford gunners the opportunity to launch small boats for harvesting migratory waterfowl in the vicinity.

There will be representatives from this agency attending the public hearing on June 27 in New London to restate the above remarks.

Very truly yours,

Lyle M. Thorpe
Director

JPG:B

EXHIBIT E-5



ADDRESS ONLY THE
REGIONAL DIRECTOR

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
59 TEMPLE PLACE
BOSTON, MASSACHUSETTS

NORTHEAST REGION
(REGION 5)
MAINE
NEW HAMPSHIRE
NEW YORK
VERMONT
PENNSYLVANIA
MASSACHUSETTS
NEW JERSEY
RHODE ISLAND
DELAWARE
CONNECTICUT
WEST VIRGINIA

August 16, 1960

Division Engineer
New England Division
U. S. Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

This preliminary report by our Bureau is in response to your notice of a public hearing of May 25, 1960, regarding hurricane tidal flood protection for New London, Connecticut. We regret that this report could not be made available at the time the public hearing on June 27 was held but would appreciate having it made a part of the record of the public hearing.

Your plan of protection against tidal flooding for the industrial and commercial area in the vicinity of Shaw Cove involves rock protected earth-fill dikes, and concrete walls extending from just south of New London Mills to the Coast Guard Pier north of Shaw Cove. The protection would include a gated navigation opening at the entrance to Shaw Cove and a small boat opening at the entrance to Bentley's Creek. A pumping station would evacuate interior drainage from the area. Openings closed by stop logs would be provided for highways and railroads.

This Bureau, with the concurrence of the Bureau of Commercial Fisheries and of the Connecticut State Board of Fisheries and Game, concludes that no significant adverse effects would occur to the fish and wildlife resources of the area

EXHIBIT E-6

as a result of the recommended barrier in the vicinity of Shaw Cove and another larger barrier to the south and west of Fort Trumbull.

The project area contains some of the finest sport fishery resources found along the coast of Connecticut. Striped bass, bluefish, mackerel, smelt, and winter flounder form the basis for this significant recreational sport fishery. Waterfowl gunning in season is a popular sport in the vicinity of the project area.

There are some opportunities in connection with the construction of the barriers to contribute to the conservation and development of fish and wildlife resources of the project area. Modification of project related developments and improvements, including access, parking, and boat launching facilities at the barriers for fishermen and waterfowl hunters, would insure maximum project benefits.

To adequately insure these benefits a detailed study of the fish and wildlife resources of the project area will be required to determine the extent of project modifications necessary. The results of such a study will relate fish and wildlife resources to project developments and improvements and public needs.

We recommend:

- (1) That modifications of the project be made to include access, parking, and boat launching for fishermen and waterfowl hunters.
- (2) That a detailed study be made of the fish and wildlife resources of the project area by this Bureau in cooperation with the Connecticut State Board of Fisheries and Game.

The opportunity to report on this study is much appreciated.

Sincerely yours,


John S. Gottschalk
Regional Director

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE

PUBLIC HEALTH SERVICE

111
BROADWAY
NEW YORK 4, N. Y.

July 25, 1960
Refer to; 24:SE

U. S. Army Engineer Division,
New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Ref.: File No. NEDGW

Dear Sir:

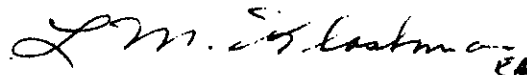
Reference is made to the Hurricane Survey, Tidal Flood Protection study of New London, Connecticut on which a public hearing was held in New London, Connecticut on the 27th of June 1960.

We have been advised by the State of Connecticut, Water Resources Commission that construction of the proposed project as shown on the map attached to your announcement of the above hearing, would block the discharge from the municipal sewage plant. We understand that this condition was brought to your attention and indication was given that the outfall would be relocated to prevent any interference.

We have no further comment on the project at this time.

For the Regional Engineer.

Sincerely yours,



Lester M. Klashman
Regional Program Director
Water Supply and Pollution
Control

NOTE: Plan provides for extension of discharge pipe from sewage treatment plant. See paragraph 65 of Report.

EXHIBIT E-7

UNITED STATES COAST GUARD

ADDRESS REPLY TO:
COMMANDER
3RD COAST GUARD DISTRICT
U. S. CUSTOM HOUSE
NEW YORK 4, N. Y.



H2-2
10 January 1961

From: Commander, Third Coast Guard District
To: U.S. Army Engineer Division, New England, Corps of Engineers,
424 Trapelo Road, Waltham 54, Massachusetts
Subj: Aids to Navigation, Proposed Plan for Hurricane Protection,
New London, Connecticut
Ref: (a) U.S. Army Engineer Division, New England ltr dtd 21 Dec 1960,
NEDGW

1. In accordance with your request contained in reference (a), you are advised that no changes are considered necessary to mark the navigation channels into Shaw Cove and Bentleys Creek. It is proposed to establish a 4 second flashing light on each of the dolphins at the entrance to the navigational openings. A total of four (4) lights in all would be required. The two (2) lights on the port hand would be flashing green every 4 seconds and the two (2) lights on the starboard hand would be flashing white every 4 seconds. These lights would be battery operated. It is estimated that the cost for each light would be \$750 for material and \$250 in labor and overhead, or a total of \$4,000 for the complete installation.

W. L. Goff
W. L. GOFF
By direction

(In a telephone conversation, Captain Goff approved a total estimate of \$12,000, based on \$4,000 for 4 lights at each opening, plus \$4,000 for warning lights indicating gate closures.)

EXHIBIT E-8
(R 7-14-61)